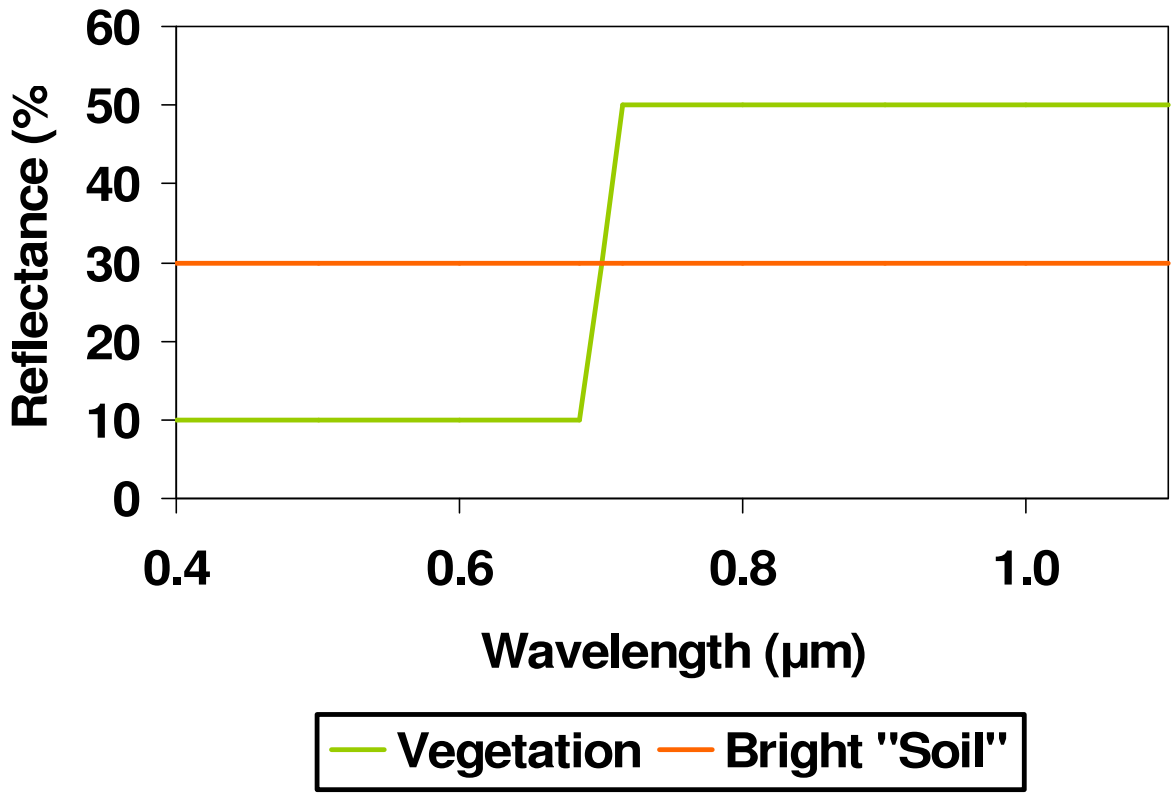
National Aeronautics and Space Administration

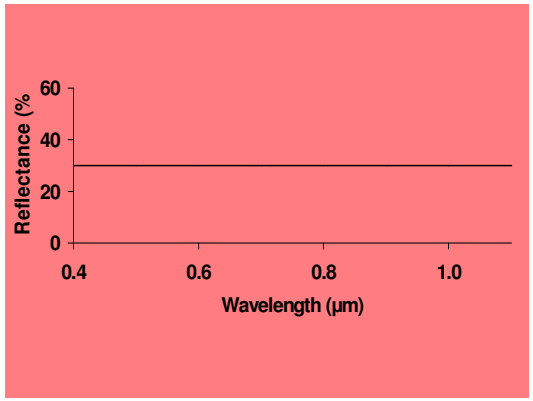
- Greetings from Mike Freilich (ESD Director) and Teresa Freiberger (ESD Applications Program Manager).
- This presentation will feature **1** technical tidbit exemplifying NASA interest in Ca/Val in GEOSS context.
- We will discuss implications of preceding example for future US observing systems.
- We will introduce you to the GEO/CEOS Data Quality Assurance Task (DA-06-02)
- We will introduce you to the GEO/CEOS WGCV Data Quality Framework

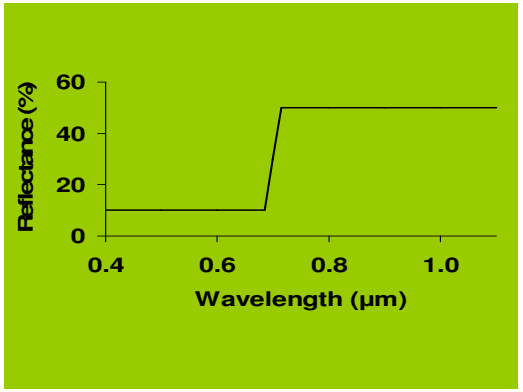
Can we expect ***perfect*** observing systems to agree with each other?

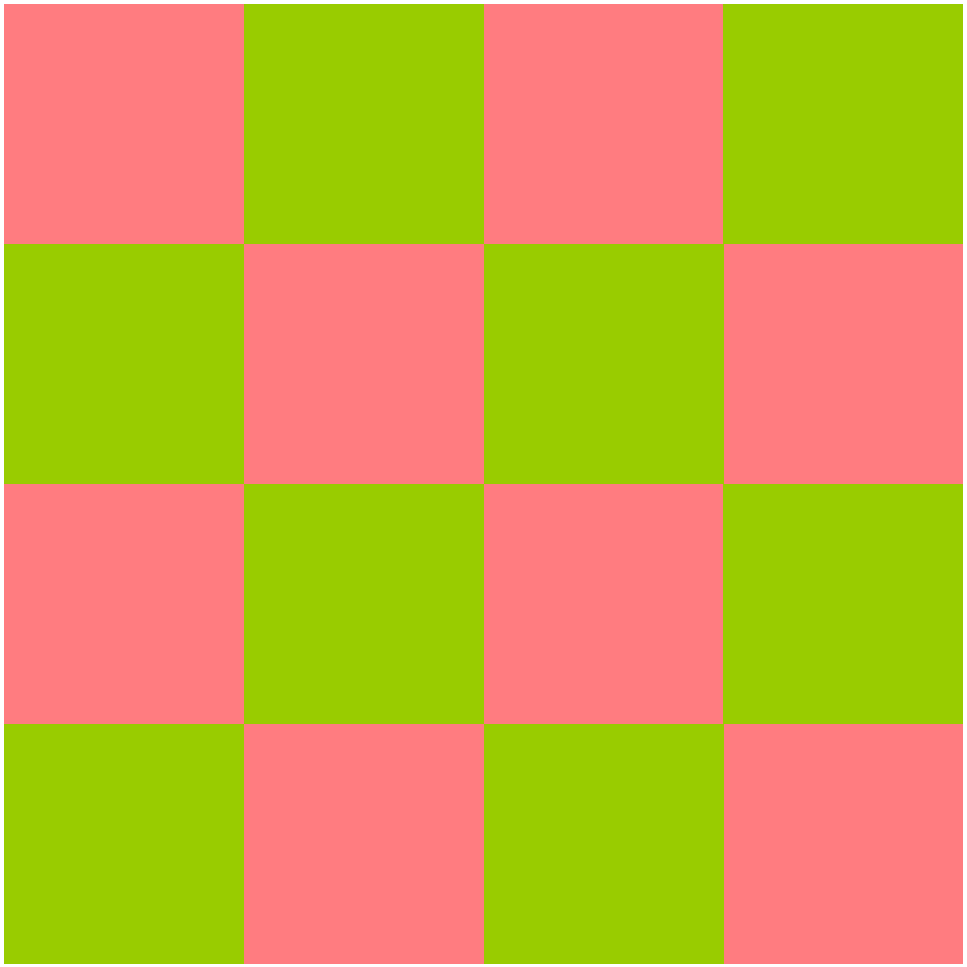
“Landscape” Components for Synthetic Scene Scenario



Synthetic Scene Composition







Landscape Reflectance Values
Synthetic Scene Scenario

.3	.5	.3	.5
.5	.3	.5	.3
.3	.5	.3	.5
.5	.3	.5	.3

NIR Reflectance

.3	.1	.3	.1
.1	.3	.1	.3
.3	.1	.3	.1
.1	.3	.1	.3

VIS Reflectance

Pixel Reflectance Values
Synthetic Scene Scenario

.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3

Nominal Position NIR Band

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

Nominal Position VIS Band

Pixel Reflectance Values
Synthetic Scene Scenario

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

Nominal Position VIS Band

Pixel Reflectance Values
Sampling Sensitivity

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

Nominal Position VIS Band

Pixel Reflectance Values
Sampling Sensitivity

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

Nominal Position VIS Band

.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2

“Half-pixel” Shift VIS Band

Pixel Reflectance Values
Sampling Sensitivity

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

Nominal Position VIS Band

.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2

“Half-pixel” Shift VIS Band

Pixel Reflectance Values
Misaligned Bands Scenario 1

.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3

Nominal Position NIR Band

.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2

“Half-pixel” Shift VIS Band

Pixel Reflectance Values
Misaligned Bands Scenario 2

.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.5	.5	.4	.3	.3	.4	.5	..5	.4	.3	.3	.4
.5	.5	.4	.3	.3	.4	.5	.5	.4	.3	.3	.4
.5	.5	.4	.3	.3	.4	.5	.5	.4	.3	.3	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.5	.5	.4	.3	.3	.4	.5	..5	.4	.3	.3	.4
.5	.5	.4	.3	.3	.4	.5	.5	.4	.3	.3	.4
.5	.5	.4	.3	.3	.4	.5	.5	.4	.3	.3	.4

“Half-pixel” Shift NIR Band

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

Nominal Position VIS Band

Study Basis

Nominal Position NIR Band

.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3

Nominal Position VIS Band

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

=

1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1

$$\frac{\text{NIR-Reflectance}}{\text{VIS-Reflectance}} = \text{VI}$$

Study Basis

Nominal Position NIR Band

.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3

Nominal Position VIS Band

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

=

1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1

$$\frac{\text{NIR-Reflectance}}{\text{VIS-Reflectance}} = \text{VI}$$

Study Basis

Nominal Position NIR Band

.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3

Nominal Position VIS Band

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

=

1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
1	1	1	5	5	5	1	1	1	5	5	5
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1
5	5	5	1	1	1	5	5	5	1	1	1

$$\frac{\text{NIR-Reflectance}}{\text{VIS-Reflectance}} = \text{VI}$$

Study Scenario 1

Nominal Position NIR Band

.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3

“Half-pixel” Shift VIS Band

.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.3	.3	.2	.1	.1	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.3	.3	.2	.1	.1	.2	.1	.1	.2	.1	.1	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2
.1	.1	.2	.3	.3	.2	.1	.1	.2	.3	.3	.2

=

1	1	1.5	5	5	2.5	1	1	1.5	5	5	2.5
1	1	1.5	5	5	2.5	1	1	1.5	5	5	2.5
1	1	1.5	5	5	2.5	1	1	1.5	5	5	2.5
5	5	2.5	1	1	1.5	5	5	2.5	1	1	1.5
5	5	2.5	1	1	1.5	5	5	2.5	1	1	1.5
5	5	2.5	1	1	1.5	5	5	2.5	1	1	1.5
1	1	1.5	5	5	2.5	1	1	1.5	5	5	2.5
1	1	1.5	5	5	2.5	1	1	1.5	5	5	2.5
1	1	1.5	5	5	2.5	1	1	1.5	5	5	2.5
5	5	2.5	1	1	1.5	5	5	2.5	1	1	1.5
5	5	2.5	1	1	1.5	5	5	2.5	1	1	1.5
5	5	2.5	1	1	1.5	5	5	2.5	1	1	1.5

$$\frac{\text{NIR-Reflectance}}{\text{VIS-Reflectance}} = \text{VI}$$

Study Scenario 1

misalignment "corrected"

Nominal Position NIR Band

.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	..5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.3	.3	.3	.5	.5	.5	.3	.3	.3	.5	.5	.5
.5	..5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3
.5	.5	.5	.3	.3	.3	.5	.5	.5	.3	.3	.3

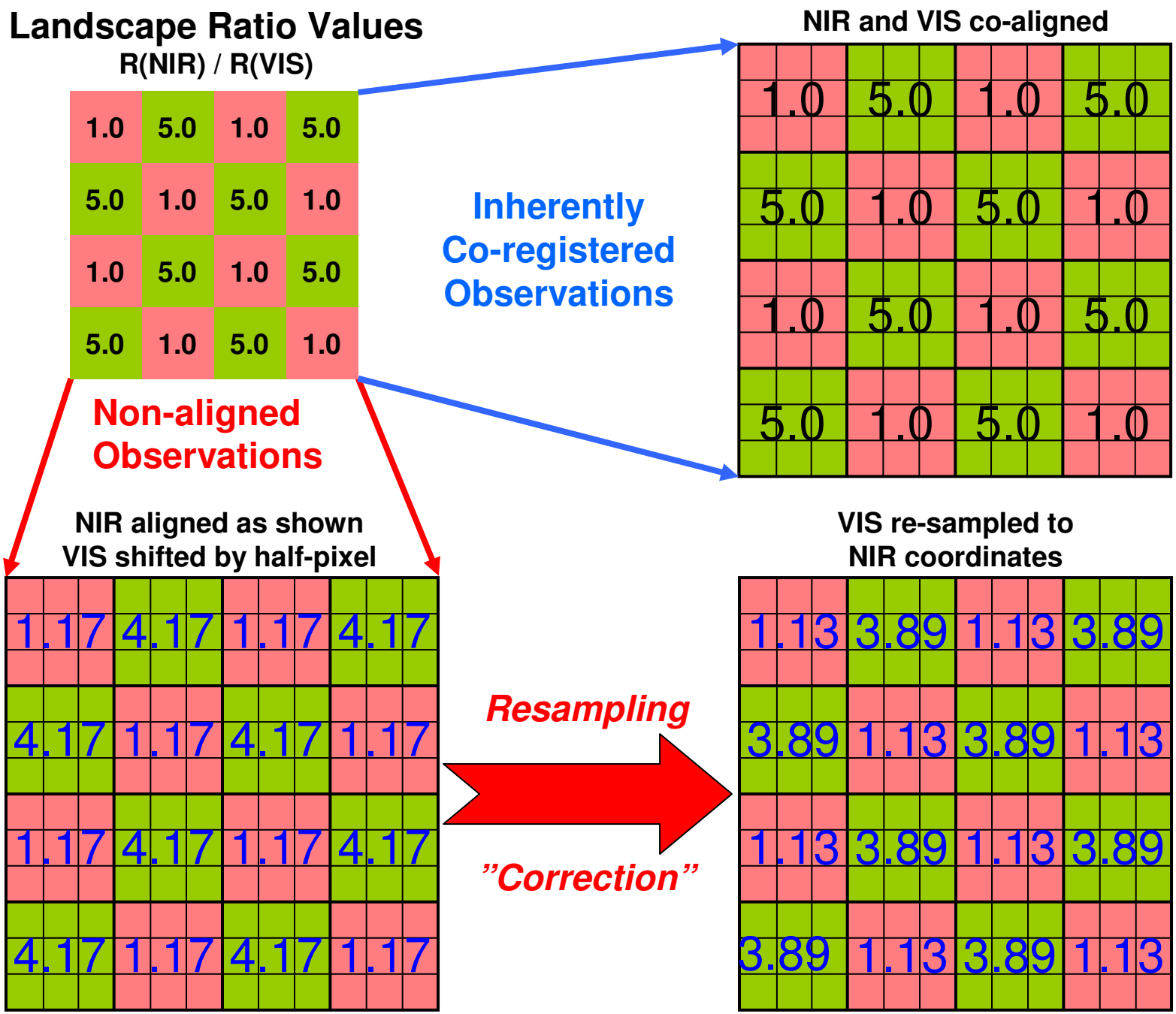
"Half-pixel" Resampled VIS Band

.25	.3	.25	.15	.1	.15	.25	.3	.25	.15	.1	.15
.25	.3	.25	.15	.1	.15	.25	.3	.25	.15	.1	.15
.25	.3	.25	.15	.1	.15	.25	.3	.25	.15	.1	.15
.15	.1	.15	.25	.3	.25	.15	.1	.15	.25	.3	.25
.15	.1	.15	.3	.3	.25	.15	.1	.15	.25	.3	.25
.15	.1	.15	.3	.3	.25	.15	.1	.15	.25	.3	.25
.25	.3	.25	.15	.1	.15	.25	.3	.25	.15	.1	.15
.25	.3	.25	.15	.1	.15	.25	.3	.25	.15	.1	.15
.25	.3	.25	.15	.1	.15	.25	.3	.25	.15	.1	.15
.15	.1	.15	.25	.3	.25	.15	.1	.15	.25	.3	.25
.15	.1	.15	.25	.3	.25	.15	.1	.15	.25	.3	.25
.15	.1	.15	.25	.3	.25	.15	.1	.15	.25	.3	.25

=

1.2	1	1.2	3.3	5	3.3	1.2	1	1.2	3.3	5	3.3
1.2	1	1.2	3.3	5	3.3	1.2	1	1.2	3.3	5	3.3
1.2	1	1.2	3.3	5	3.3	1.2	1	1.2	3.3	5	3.3
3.3	5	3.3	1.2	1	1.2	3.3	5	3.3	1.2	1	1.2
3.3	5	3.3	1.2	1	1.2	3.3	5	3.3	1.2	1	1.2
3.3	5	3.3	1.2	1	1.2	3.3	5	3.3	1.2	1	1.2
1.2	1	1.2	3.3	5	3.3	1.2	1	1.2	3.3	5	3.3
1.2	1	1.2	3.3	5	3.3	1.2	1	1.2	3.3	5	3.3
1.2	1	1.2	3.3	5	3.3	1.2	1	1.2	3.3	5	3.3
3.3	5	3.3	1.2	1	1.2	3.3	5	3.3	1.2	1	1.2
3.3	5	3.3	1.2	1	1.2	3.3	5	3.3	1.2	1	1.2
3.3	5	3.3	1.2	1	1.2	3.3	5	3.3	1.2	1	1.2

$$\frac{\text{NIR-Reflectance}}{\text{VIS-Reflectance}} = \text{VI}$$


Landscape Ratio Values
R(NIR) / R(VIS)
1.0 5.0 1.0 5.0
5.0 1.0 5.0 1.0
1.0 5.0 1.0 5.0
5.0 1.0 5.0 1.0
Inherently Co-registered Observations
NIR and VIS co-aligned
1.0 5.0 1.0 5.0
5.0 1.0 5.0 1.0
1.0 5.0 1.0 5.0
5.0 1.0 5.0 1.0
Non-aligned Observations
NIR aligned as shown
VIS shifted by half-pixel
1.17 4.17 1.17 4.17
4.17 1.17 4.17 1.17
1.17 4.17 1.17 4.17
4.17 1.17 4.17 1.17
Resampling
"Correction"
VIS re-sampled to NIR coordinates
1.13 3.89 1.13 3.89
3.89 1.13 3.89 1.13
1.13 3.89 1.13 3.89
3.89 1.13 3.89 1.13

Results of half pixel misalignment and correction through linear resampling

Scenario 1	Category 1 Ratio Value	Category 1 Discrepancy	Category 2 Ratio Value	Category 2 Discrepancy
VIS and NIR co-aligned	1.00	0%	5.00	0%
VIS and NIR misaligned	1.17	+17%	4.17	-17%
VIS realigned by resampling	1.13	+13%	3.89	-22%

Study Scenario 2

"Half-pixel" Shift NIR Band

.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.5	.5	.4	.3	.3	.4	.5	..5	.4	.3	.3	.4
.5	.5	.4	.3	.3	.4	.5	.5	.4	.3	.3	.4
.5	.5	.4	.3	.3	.4	.5	.5	.4	.3	.3	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.3	.3	.4	.5	.5	.4	.3	.3	.4	.5	.5	.4
.5	.5	.4	.3	.3	.4	.5	..5	.4	.3	.3	.4
.5	.5	.4	.3	.3	.4	.5	.5	.4	.3	.3	.4
.5	.5	.4	.3	.3	.4	.5	.5	.4	.3	.3	.4

Nominal Position VIS Band

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

=

1	1	1.3	5	5	4	1	1	1.3	5	5	4
1	1	1.3	5	5	4	1	1	1.3	5	5	4
1	1	1.3	5	5	4	1	1	1.3	5	5	4
5	5	4	1	1	1.3	5	5	4	1	1	1.3
5	5	4	1	1	1.3	`5	5	4	1	1	1.3
5	5	4	1	1	1.3	5	5	4	1	1	1.3
1	1	1.3	5	5	4	1	1	1.3	5	5	4
1	1	1.3	5	5	4	1	1	1.3	5	5	4
1	1	1.3	5	5	4	1	1	1.3	5	5	4
5	5	4	1	1	1.3	5	5	4	1	1	1.3
5	5	4	1	1	1.3	5	5	4	1	1	1.3
5	5	4	1	1	1.3	5	5	4	1	1	1.3

$$\frac{\text{NIR-Reflectance}}{\text{VIS-Reflectance}} = \text{VI}$$

Study Scenario 2

misalignment "corrected"

"Half-pixel" Resampled NIR Band

.35	.3	.35	.45	.5	.45	.35	.3	.35	.45	.5	.45
.35	.3	.35	.45	.5	.45	.35	.3	.35	.45	.5	.45
.35	.3	.35	.45	.5	.45	.35	.3	.35	.45	.5	.45
.45	.5	.45	.35	.3	.35	.45	.5	.45	.35	.3	.35
.45	.5	.45	.35	.3	.35	.45	.5	.45	.35	.3	.35
.45	.5	.45	.35	.3	.35	.45	.5	.45	.35	.3	.35
.35	.3	.35	.45	.5	.45	.35	.3	.35	.45	.5	.45
.35	.3	.35	.45	.5	.45	.35	.3	.35	.45	.5	.45
.35	.3	.35	.45	.5	.45	.35	.3	.35	.45	.5	.45
.45	.5	.45	.35	.3	.35	.45	.5	.45	.35	.3	.35
.45	.5	.45	.35	.3	.35	.45	.5	.45	.35	.3	.35
.45	.5	.45	.35	.3	.35	.45	.5	.45	.35	.3	.35

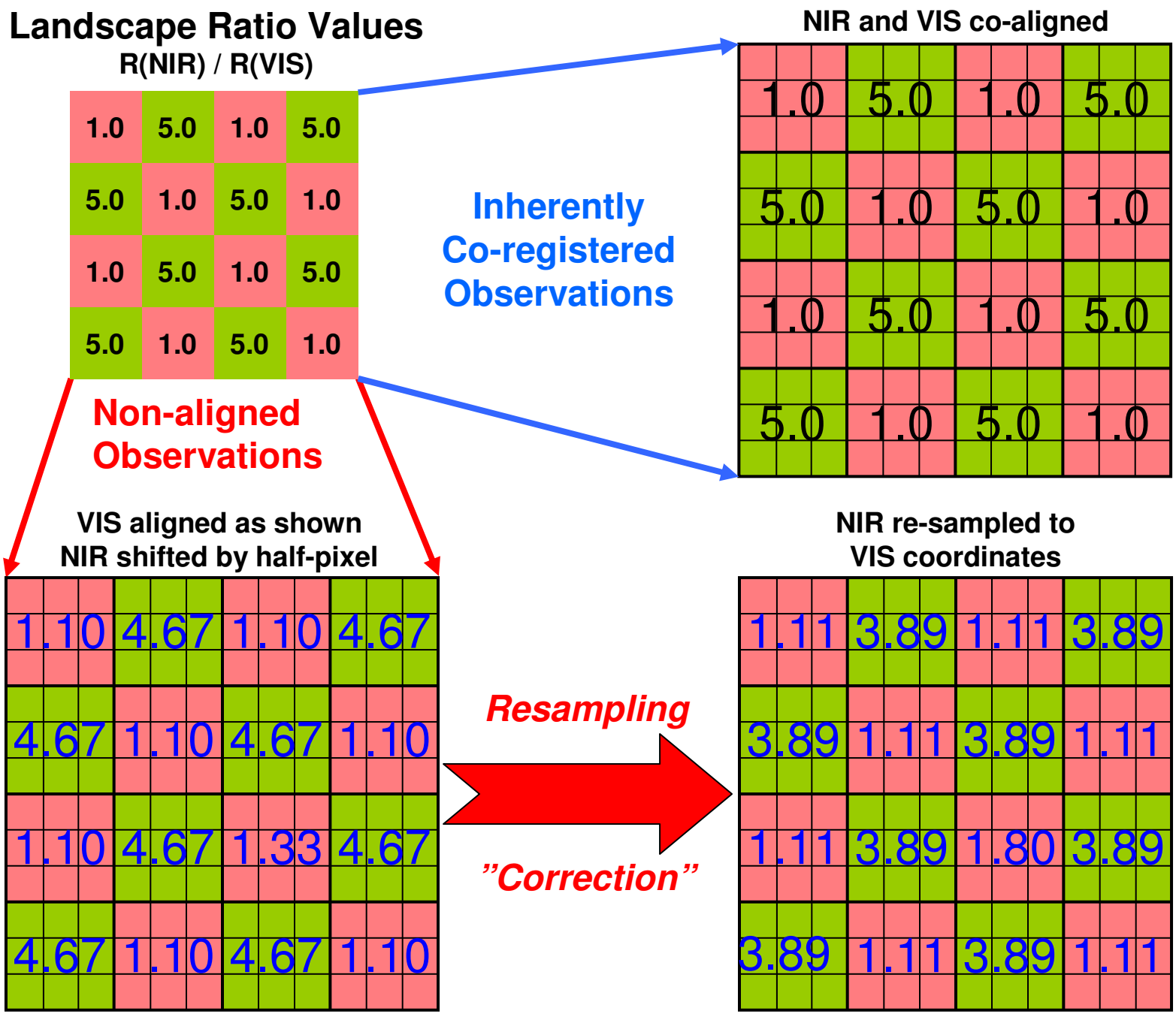
Nominal Position VIS Band

.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.3	.3	.3	.1	.1	.1	.3	.3	.3	.1	.1	.1
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3
.1	.1	.1	.3	.3	.3	.1	.1	.1	.3	.3	.3

=

1.2	1	1.2	4.5	5	4.5	1.2	1	1.2	4.5	5	4.5
1.2	1	1.2	4.5	5	4.5	1.2	1	1.2	4.5	5	4.5
1.2	1	1.2	4.5	5	4.5	1.2	1	1.2	4.5	5	4.5
4.5	5	4.5	1.2	1	1.2	4.5	5	4.5	1.2	1	1.2
4.5	5	4.5	1.2	1	1.2	4.5	5	4.5	1.2	1	1.2
4.5	5	4.5	1.2	1	1.2	4.5	5	4.5	1.2	1	1.2
1.2	1	1.2	4.5	5	4.5	1.2	1	1.2	4.5	5	4.5
1.2	1	1.2	4.5	5	4.5	1.2	1	1.2	4.5	5	4.5
1.2	1	1.2	4.5	5	4.5	1.2	1	1.2	4.5	5	4.5
4.5	5	4.5	1.2	1	1.2	4.5	5	4.5	1.2	1	1.2
4.5	5	4.5	1.2	1	1.2	4.5	5	4.5	1.2	1	1.2
4.5	5	4.5	1.2	1	1.2	4.5	5	4.5	1.2	1	1.2

$$\frac{\text{NIR-Reflectance}}{\text{VIS-Reflectance}} = \text{VI}$$

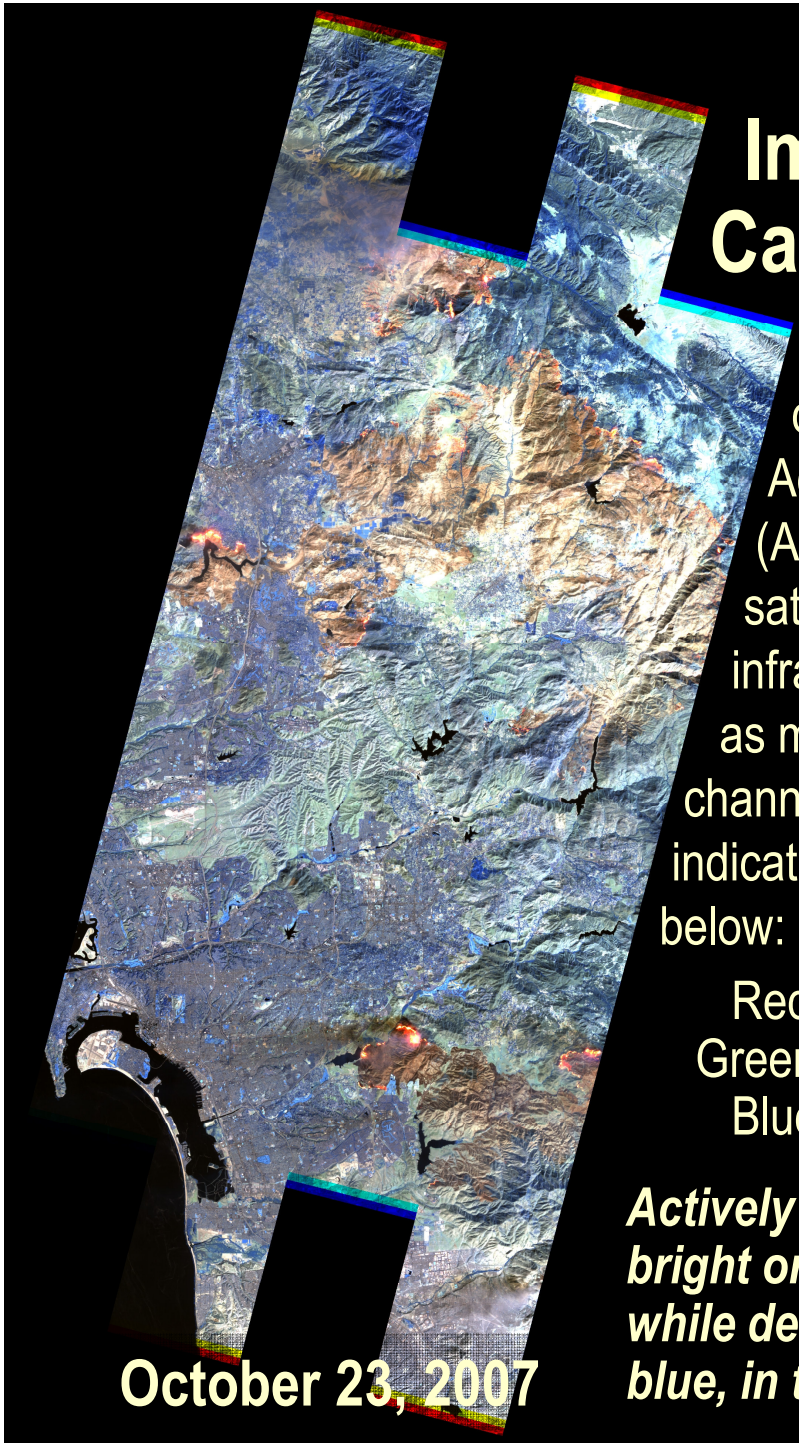

Landscape Ratio Values
R(NIR) / R(VIS)
1.0 5.0 1.0 5.0
5.0 1.0 5.0 1.0
1.0 5.0 1.0 5.0
5.0 1.0 5.0 1.0
Inherently Co-registered Observations
NIR and VIS co-aligned
1.0 5.0 1.0 5.0
5.0 1.0 5.0 1.0
1.0 5.0 1.0 5.0
5.0 1.0 5.0 1.0
Non-aligned Observations
VIS aligned as shown
NIR shifted by half-pixel
1.10 4.67 1.10 4.67
4.67 1.10 4.67 1.10
1.10 4.67 1.33 4.67
4.67 1.10 4.67 1.10
Resampling
"Correction"
NIR re-sampled to VIS coordinates
1.11 3.89 1.11 3.89
3.89 1.11 3.89 1.11
1.11 3.89 1.80 3.89
3.89 1.11 3.89 1.11

Results of half pixel misalignment and correction through linear resampling

Scenario 2	Category 1 Ratio Value	Category 1 Discrepancy	Category 2 Ratio Value	Category 2 Discrepancy
VIS and NIR co-aligned	1.00	0%	5.00	0%
VIS and NIR misaligned	1.10	+10%	4.67	-7%
NIR realigned by resampling	1.11	+11%	4.67	-7%

Is the preceding analysis relevant to planned observing systems?

EO-1 ALI Images Southern California Wildfires

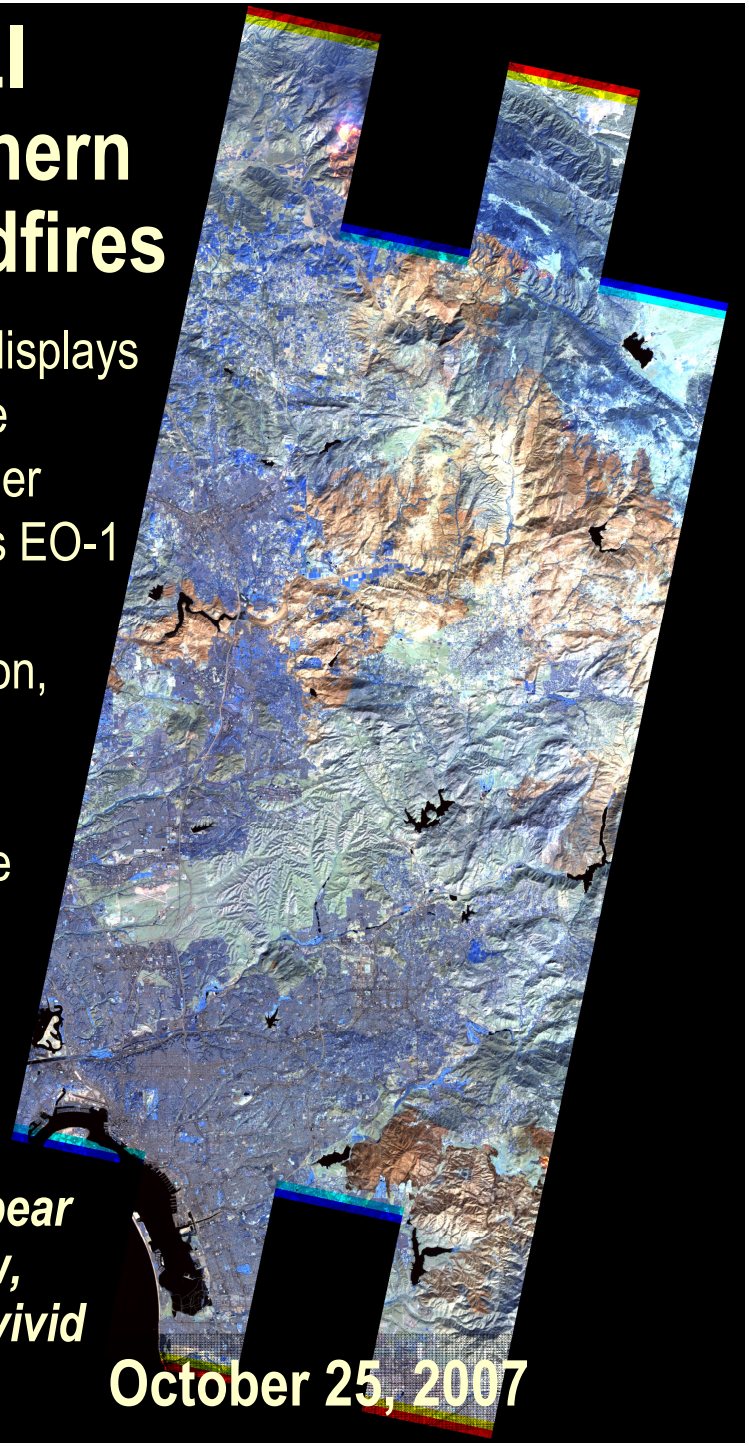


October 23, 2007

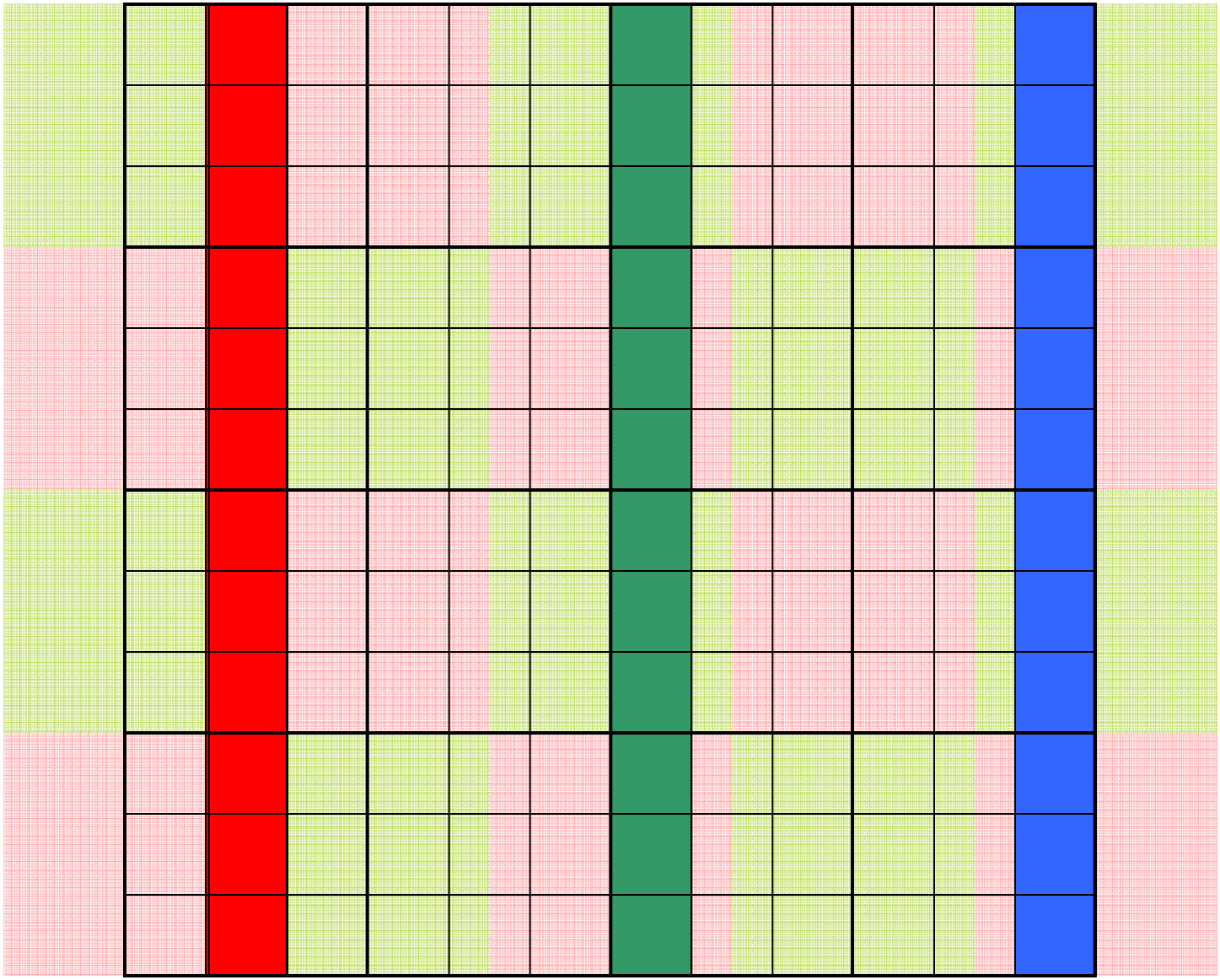
This visualization displays data acquired by the Advanced Land Imager (ALI) onboard NASA's EO-1 satellite. Shortwave infrared surface radiation, as measured in three channels, is displayed as indicated in the color guide below:

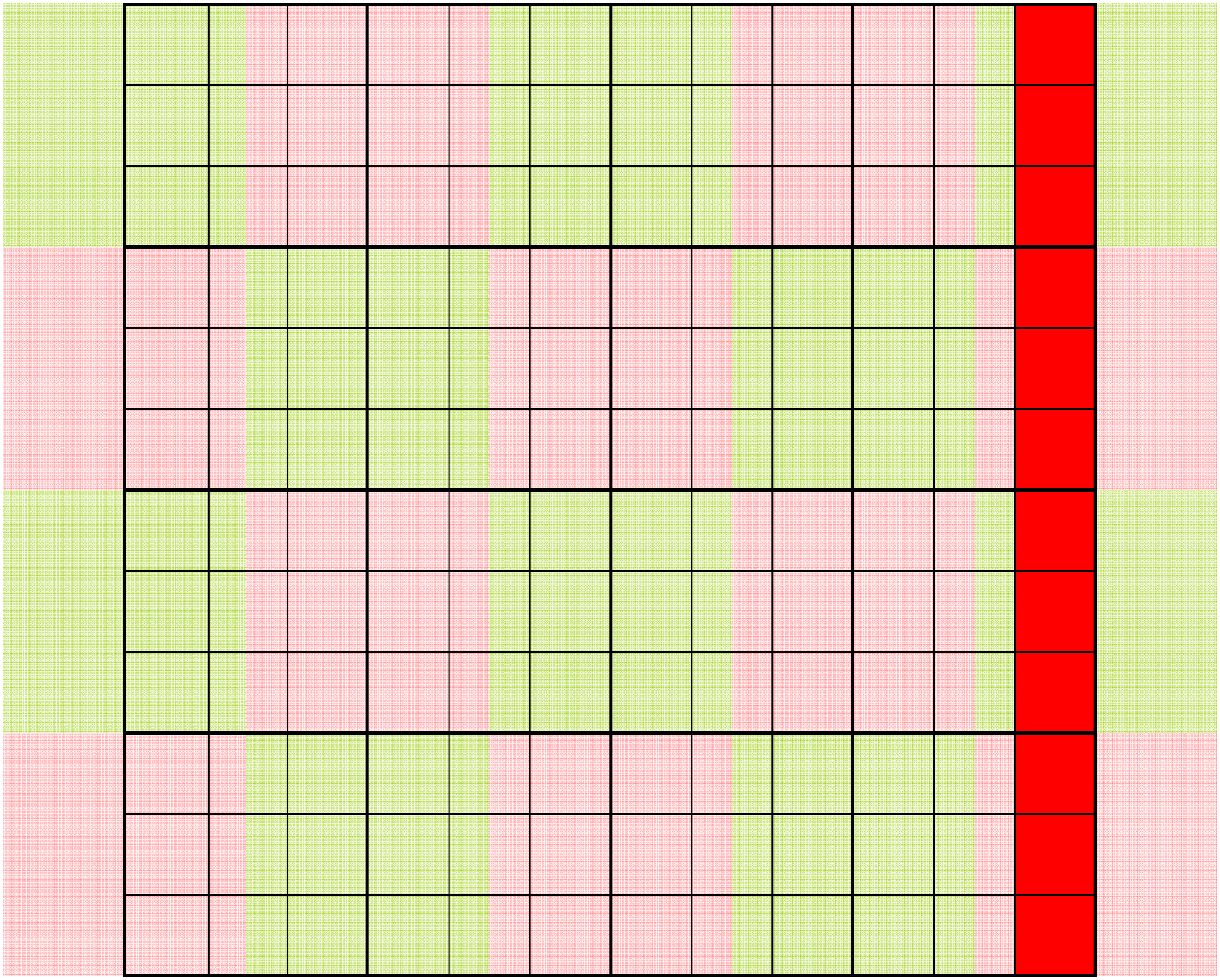
Red: 2.08-2.35μm
Green: 1.55-1.75μm
Blue: 1.20-1.30μm

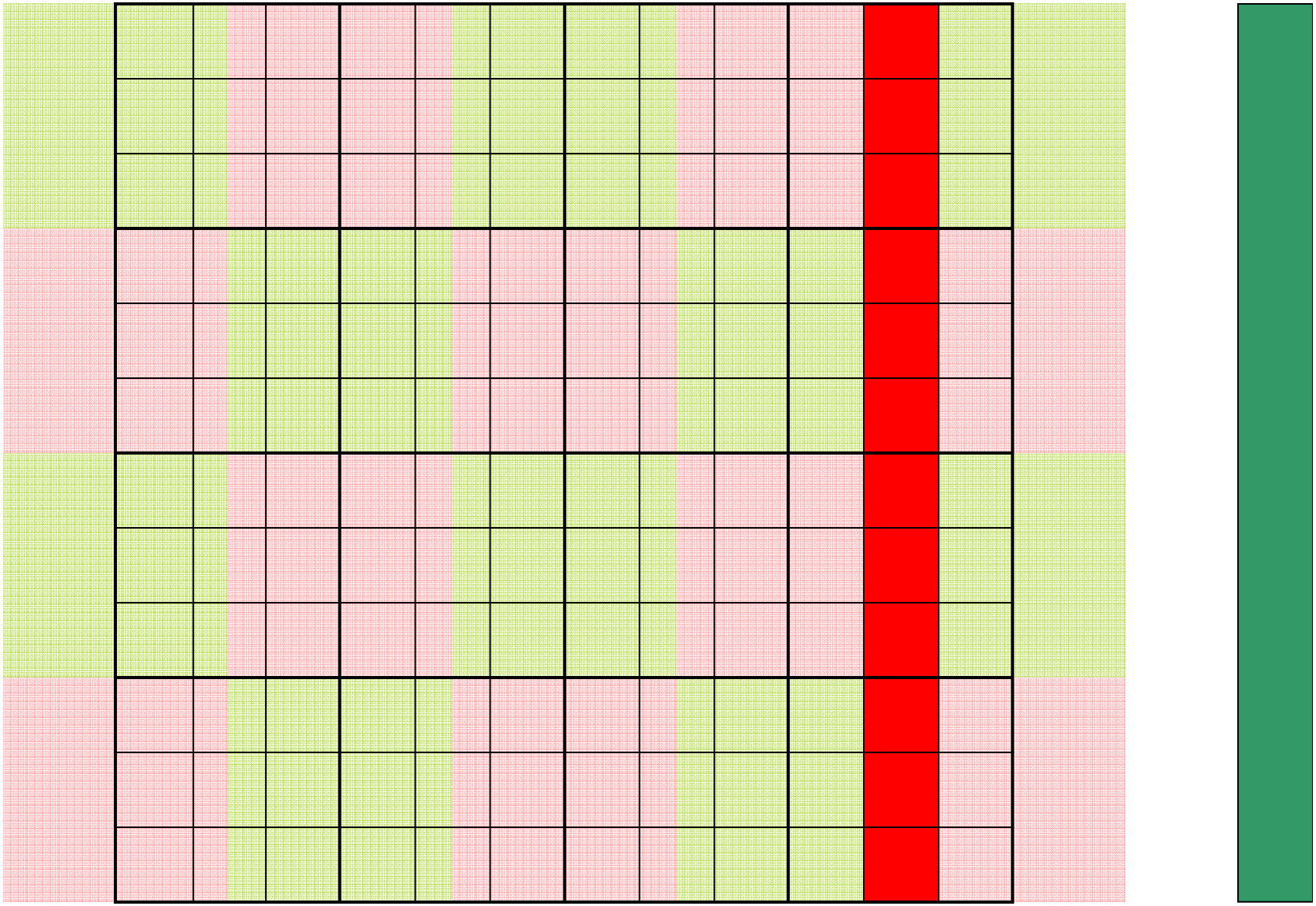
Actively burning areas appear bright orange-red to yellow, while dense vegetation is vivid blue, in this rendition.

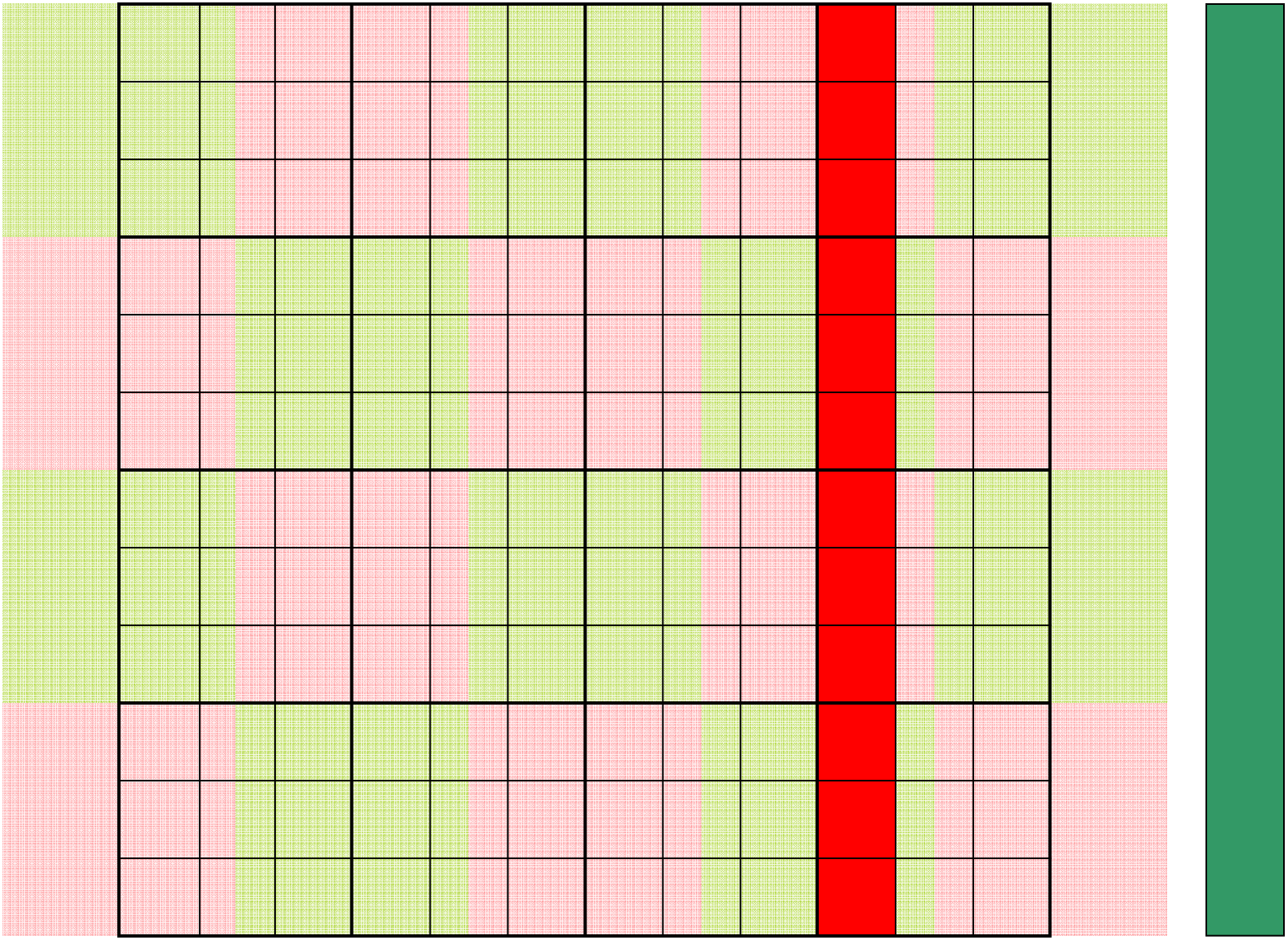


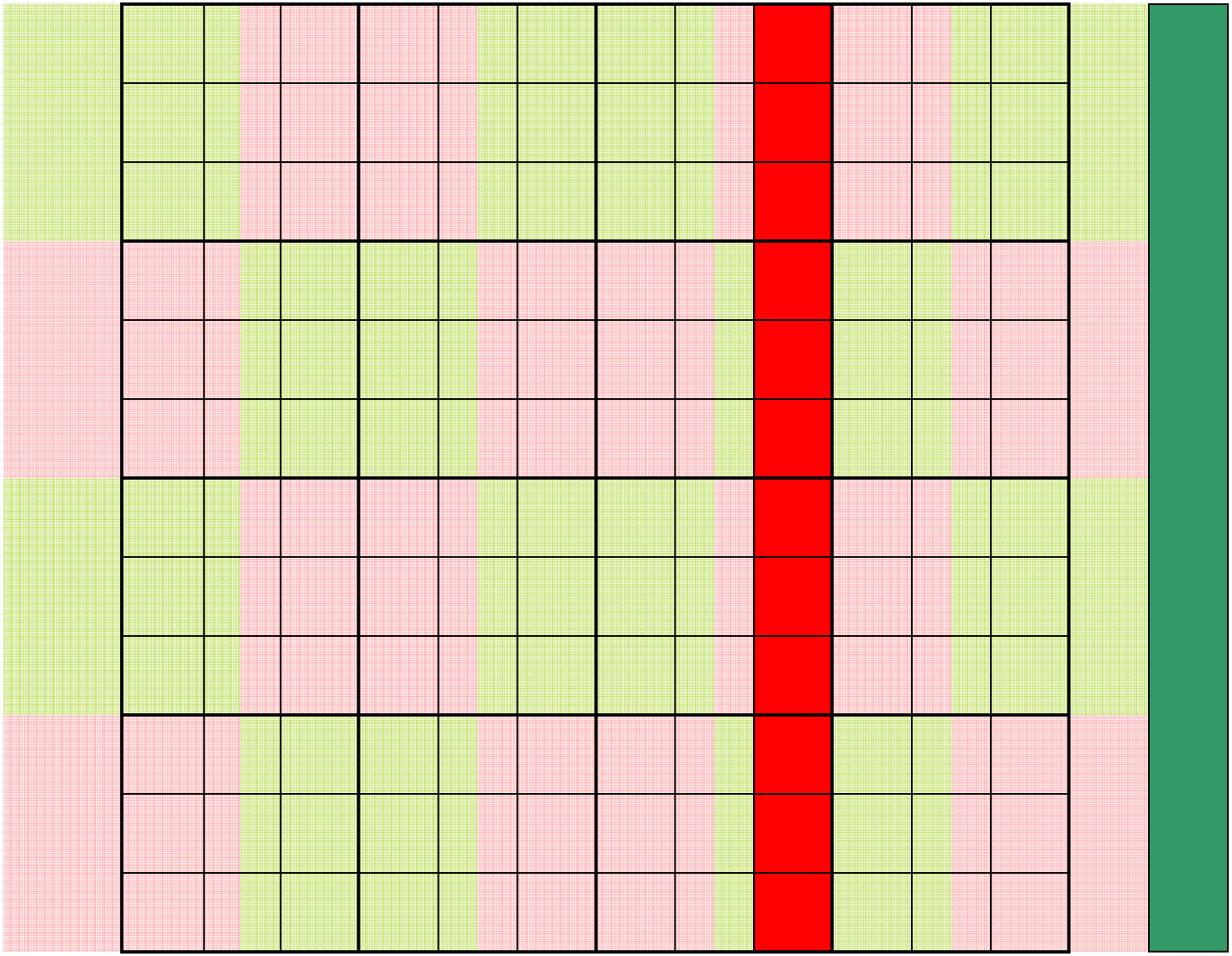
October 25, 2007

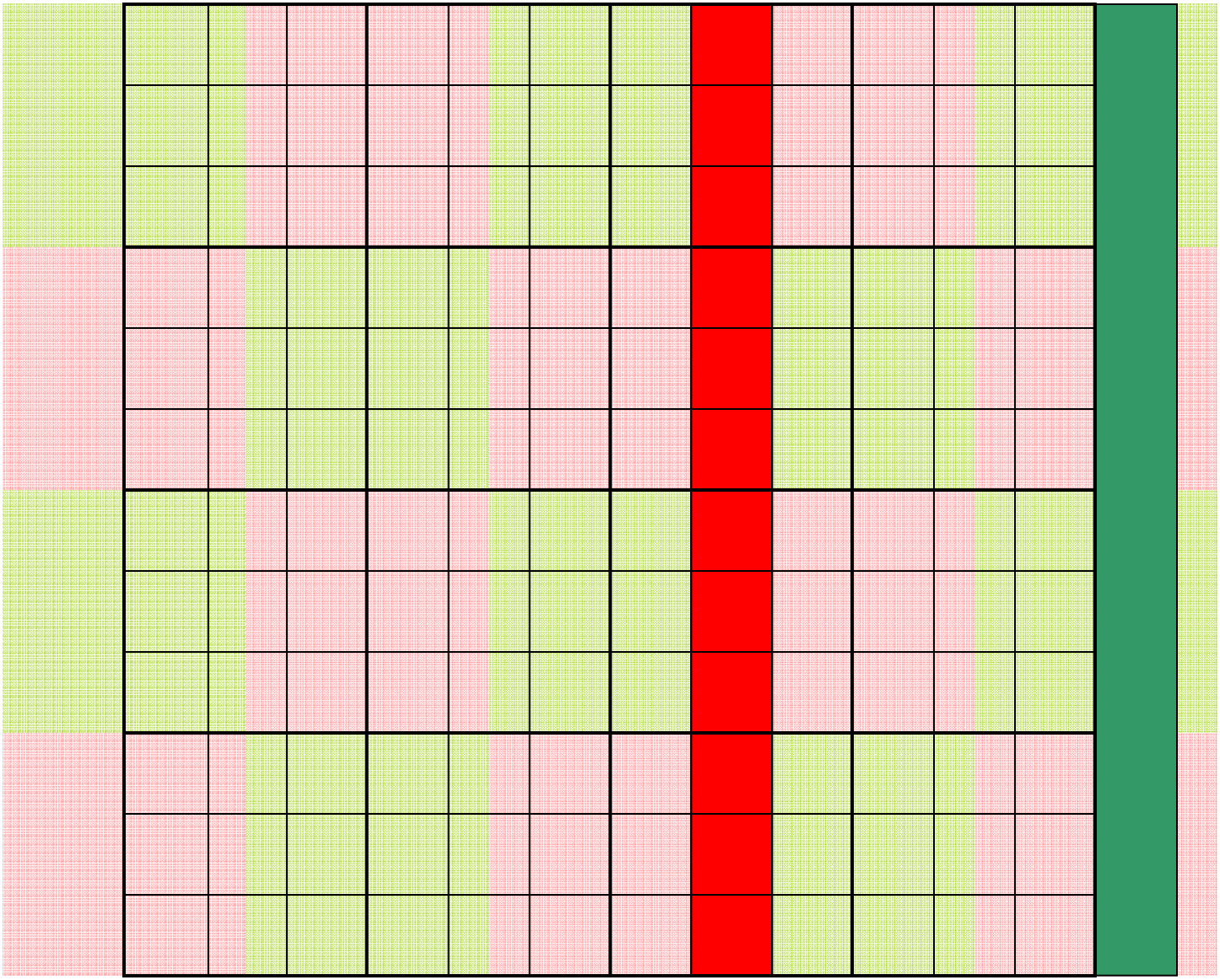


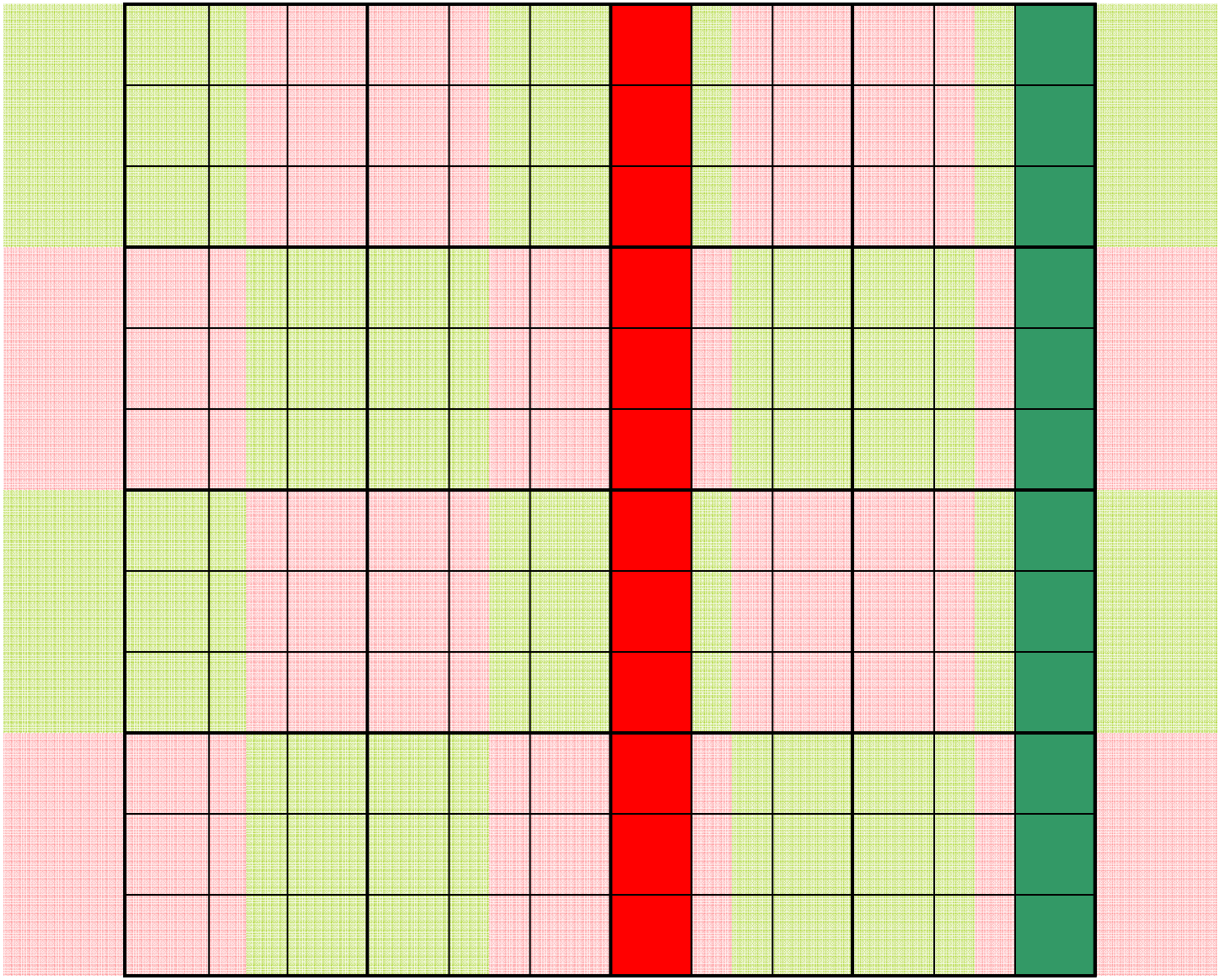


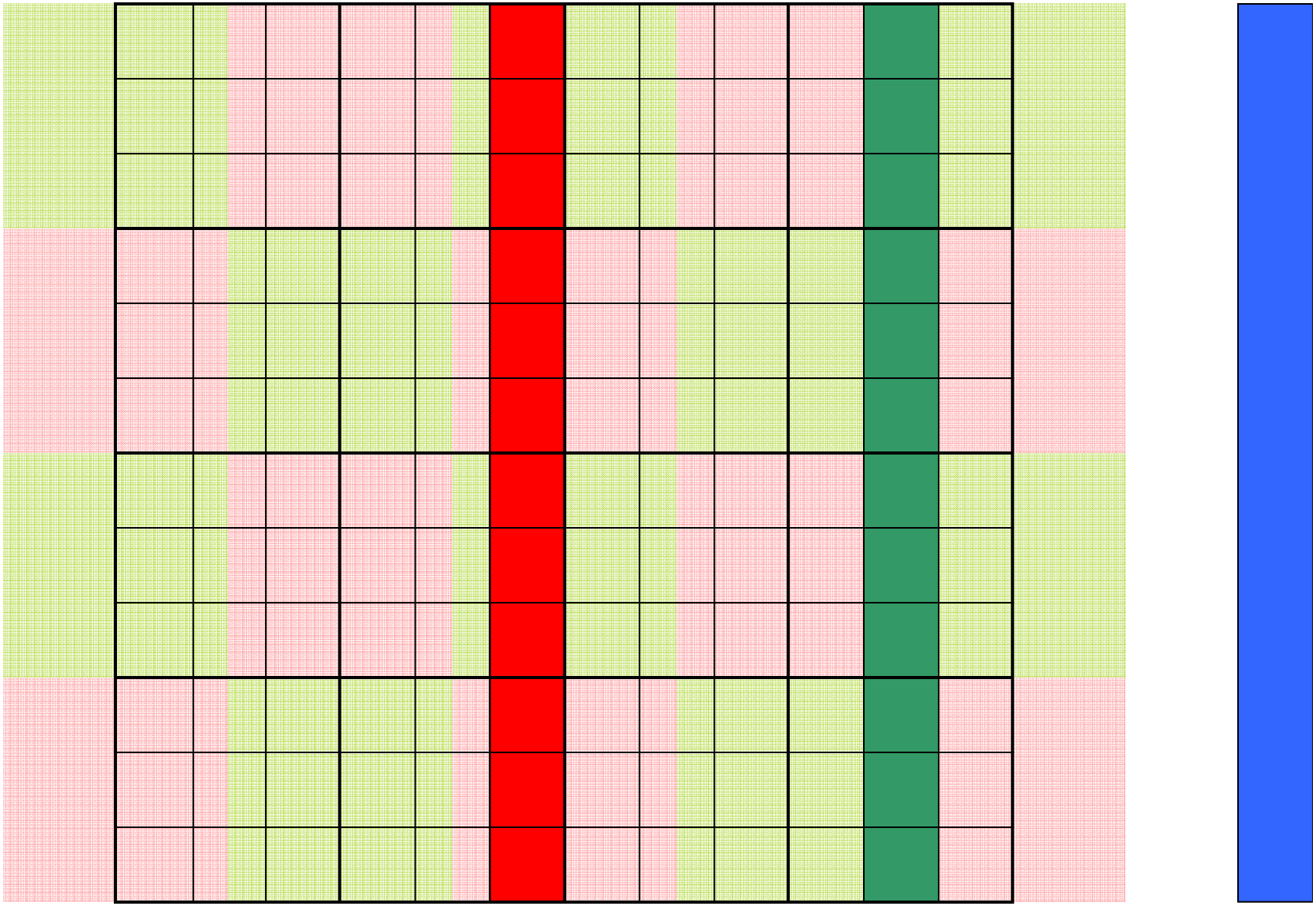


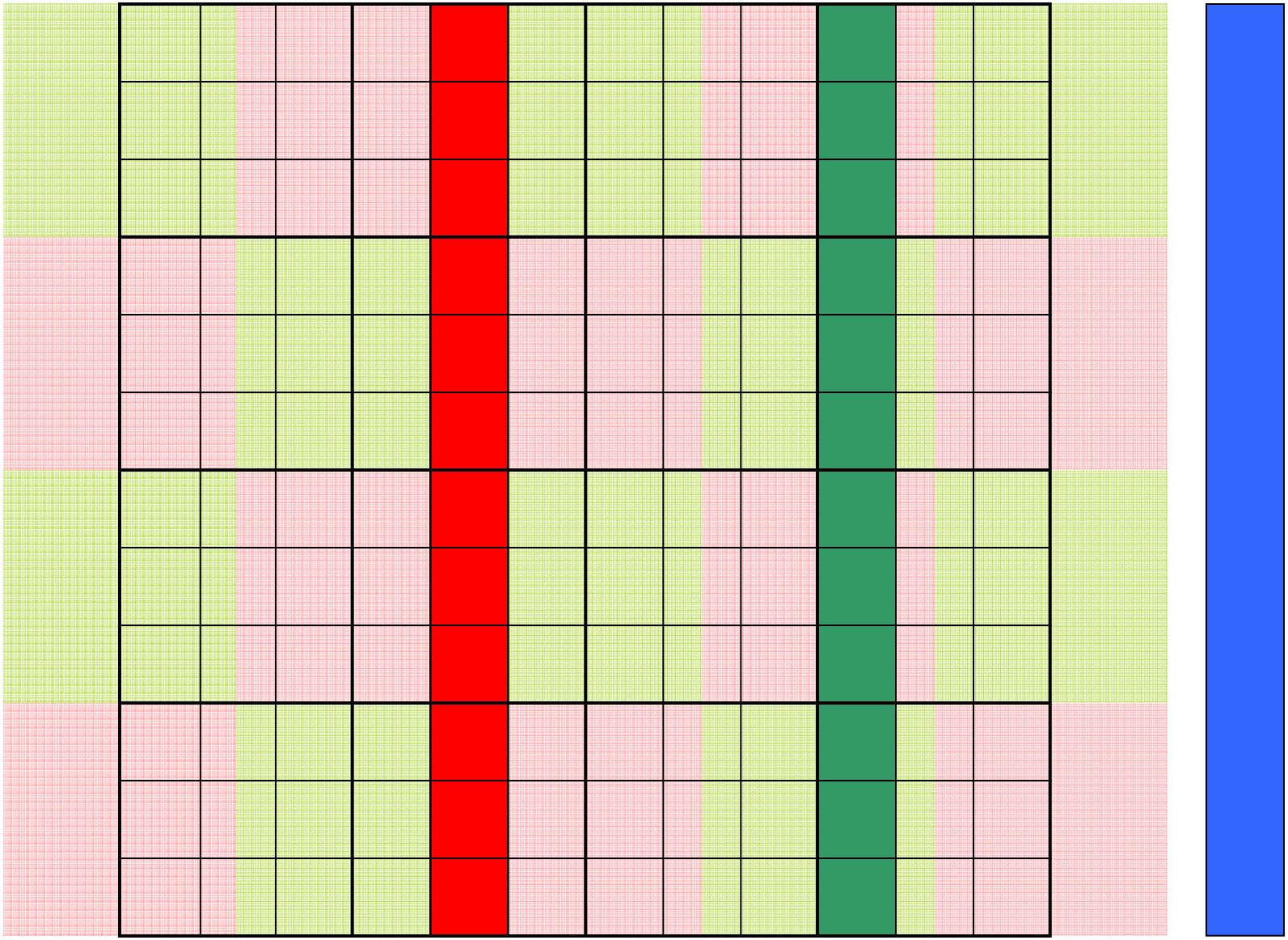


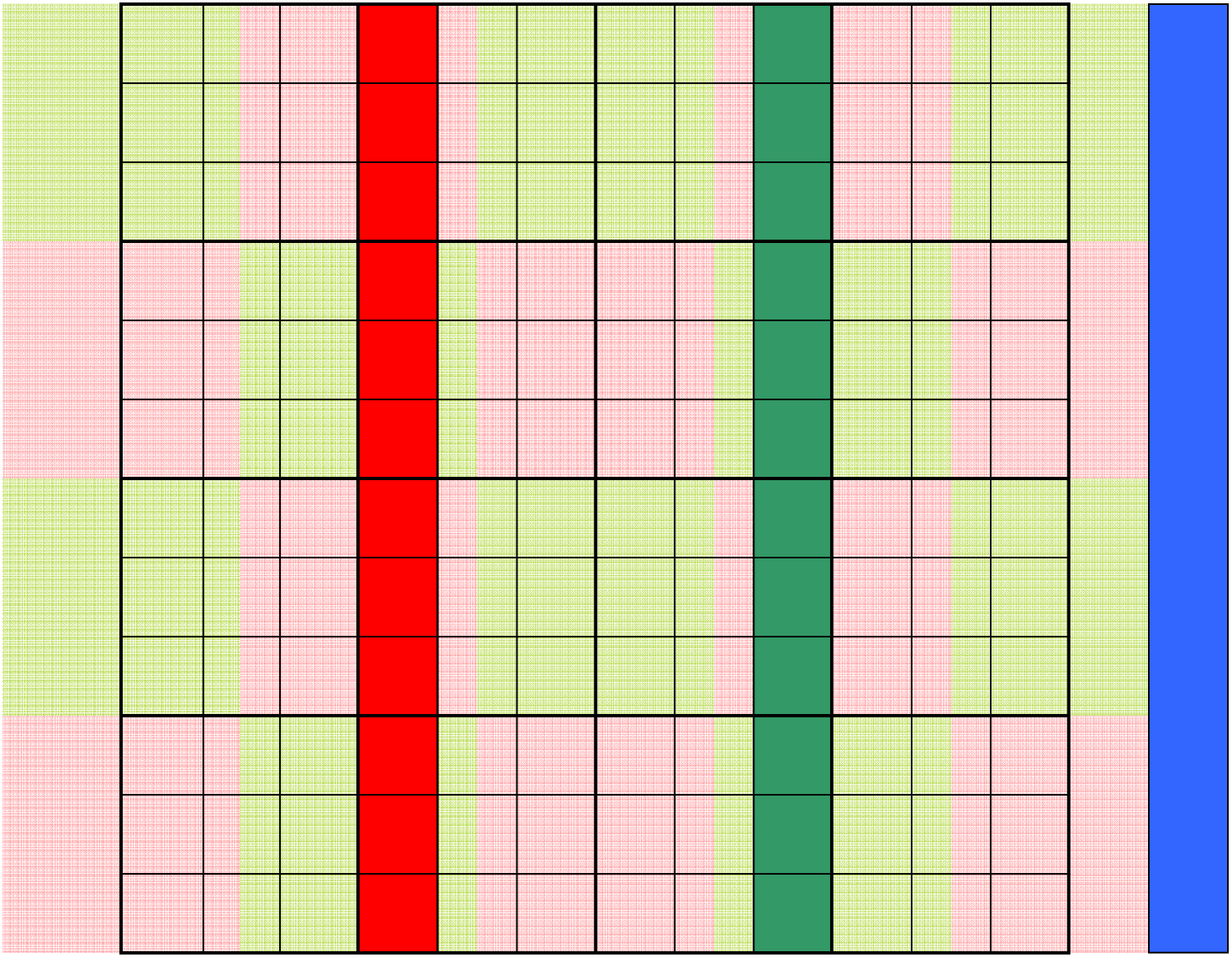


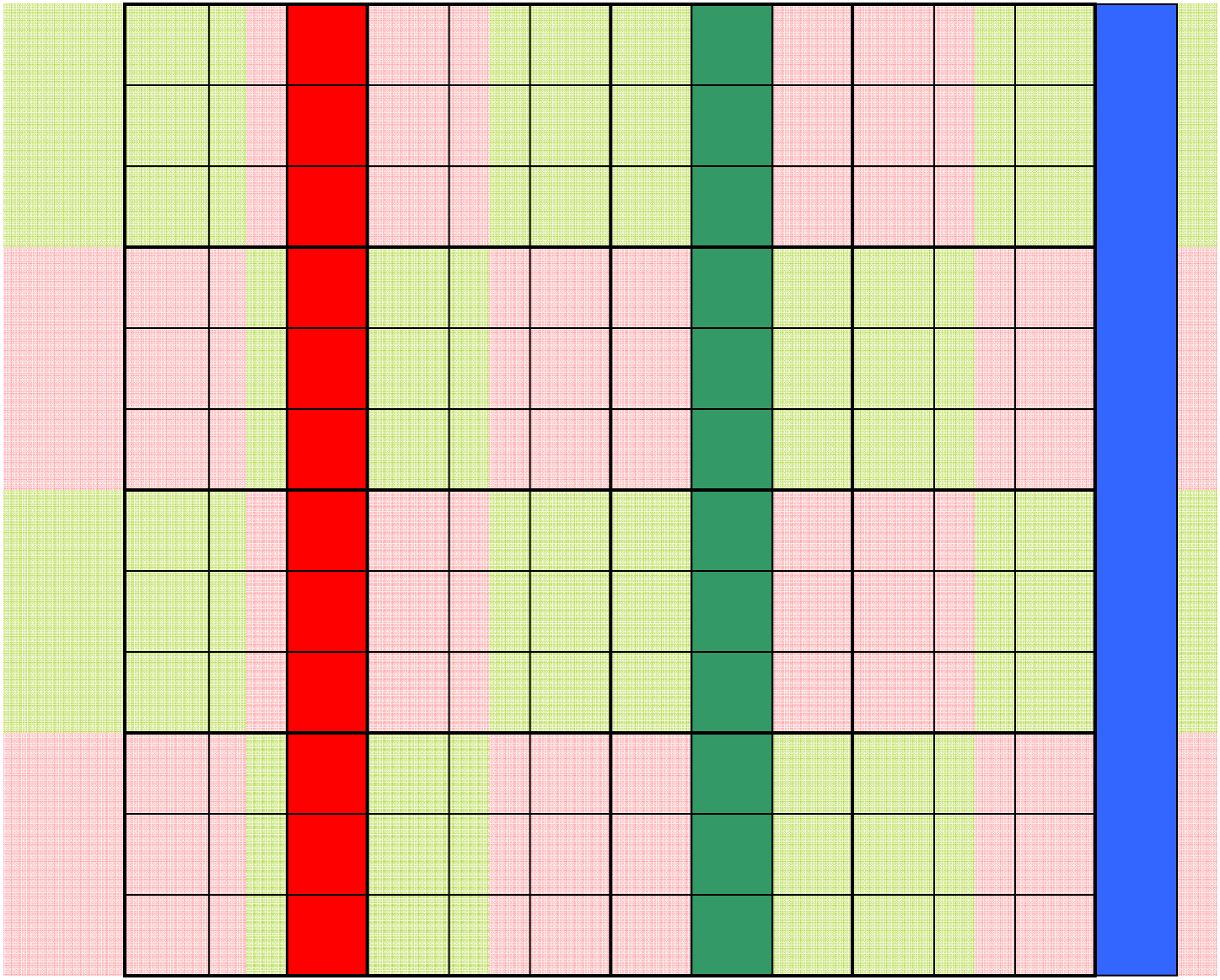


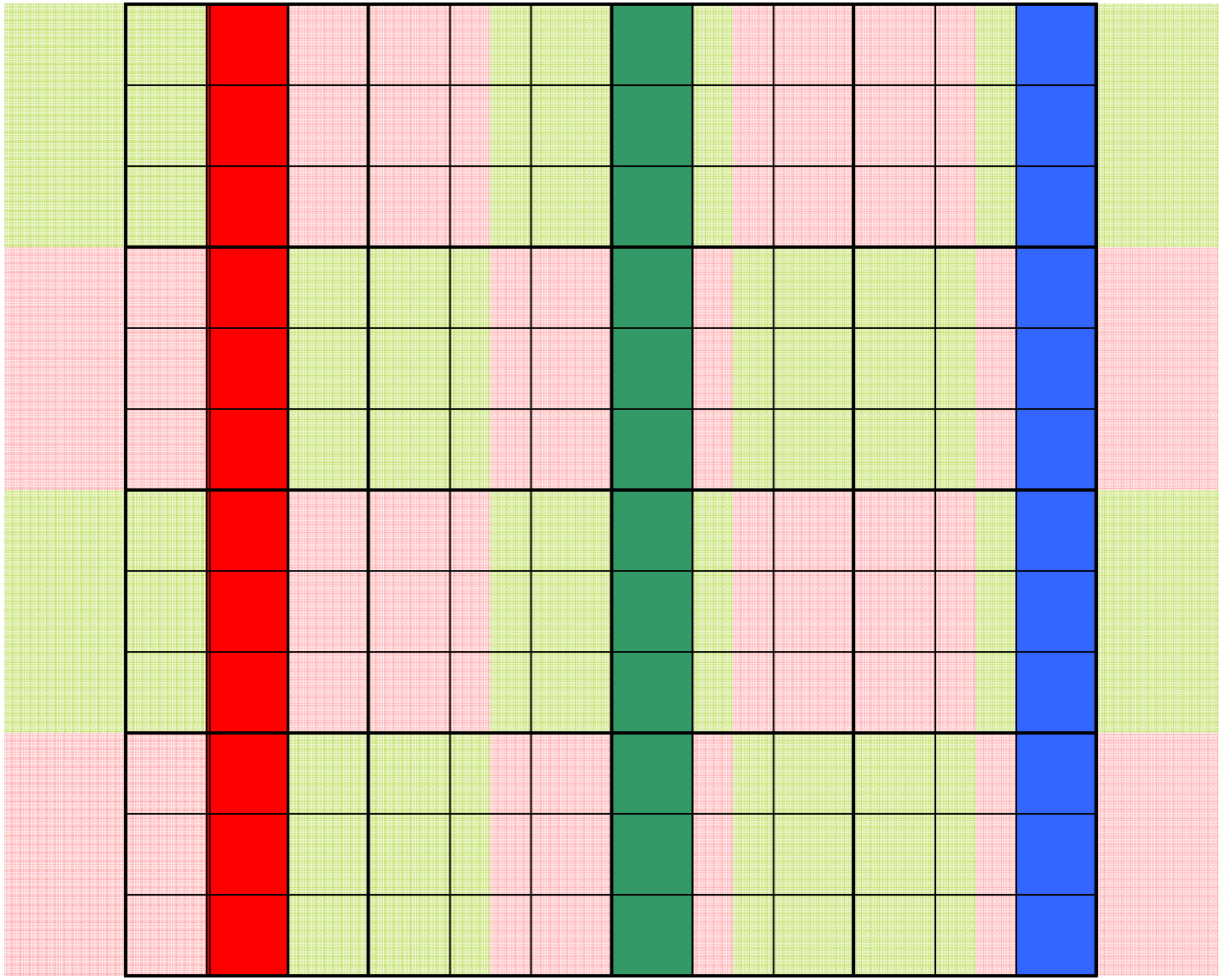


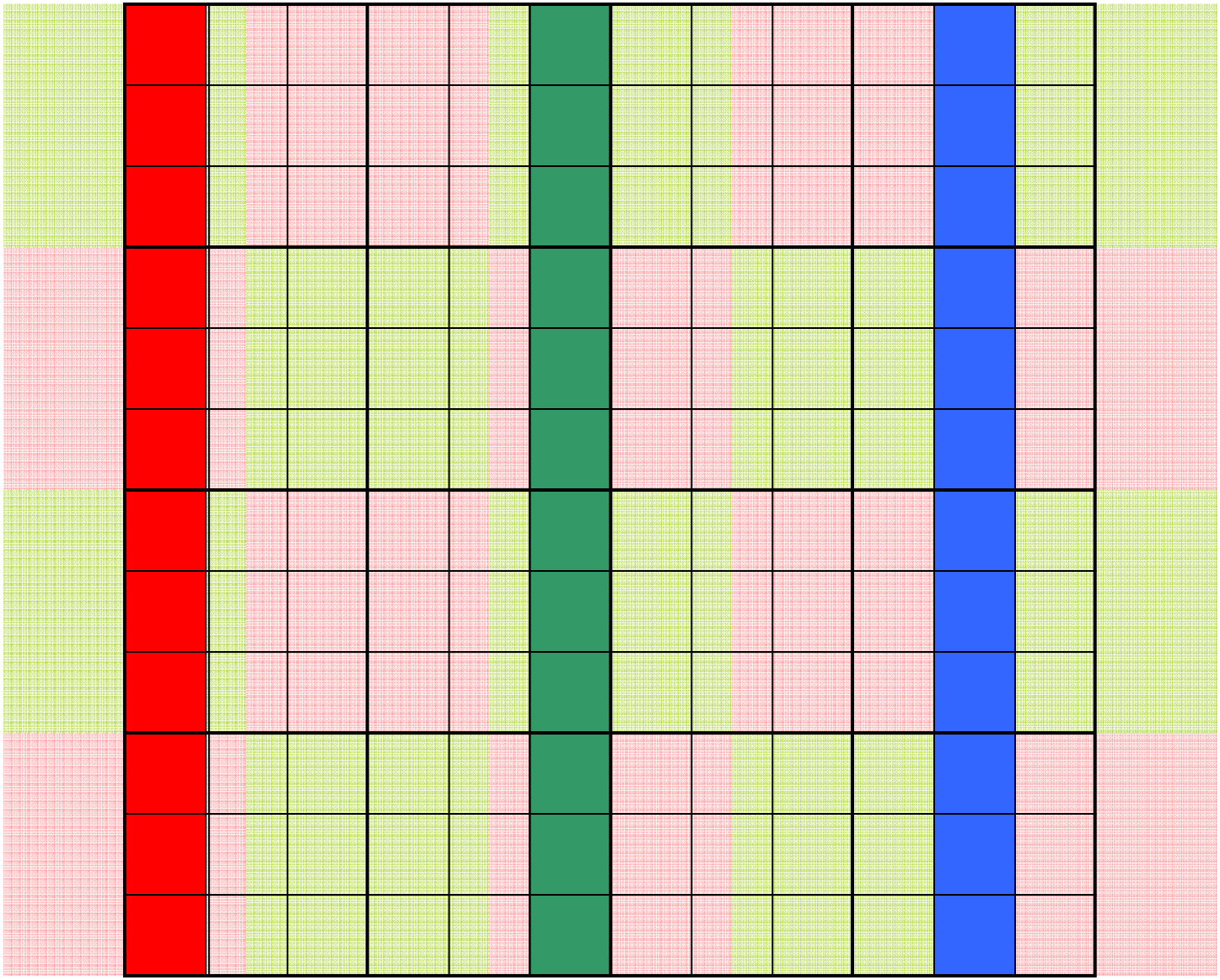


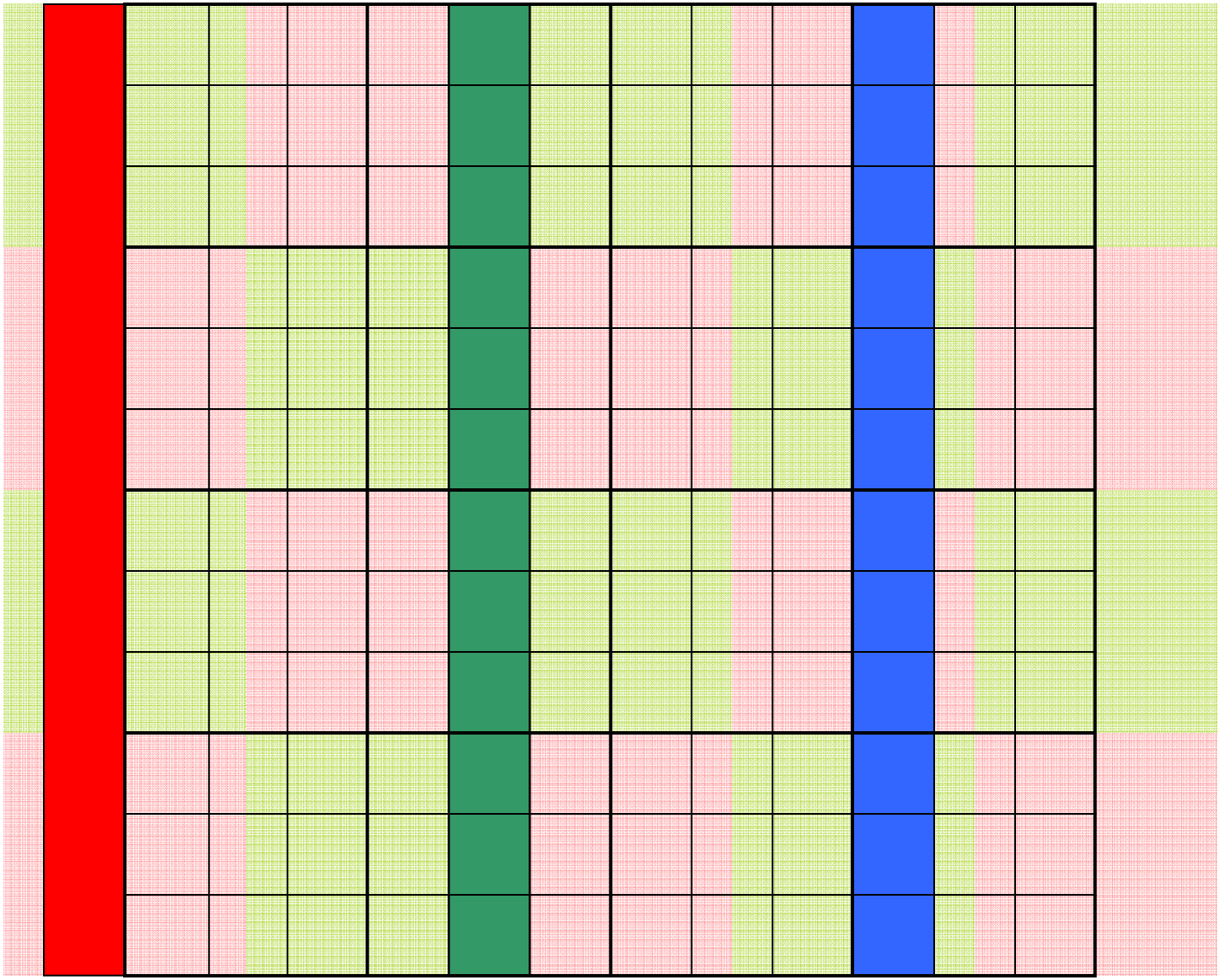


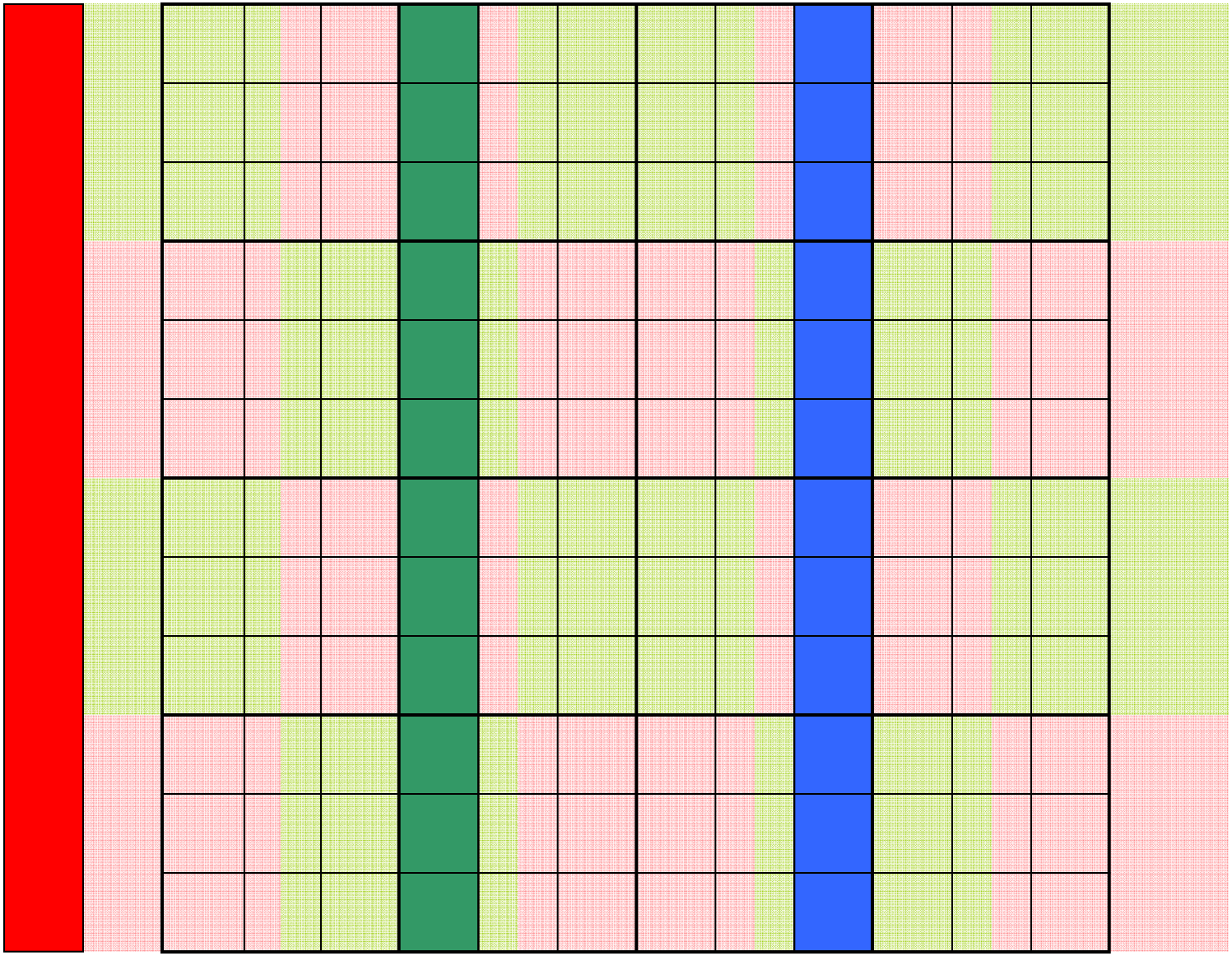


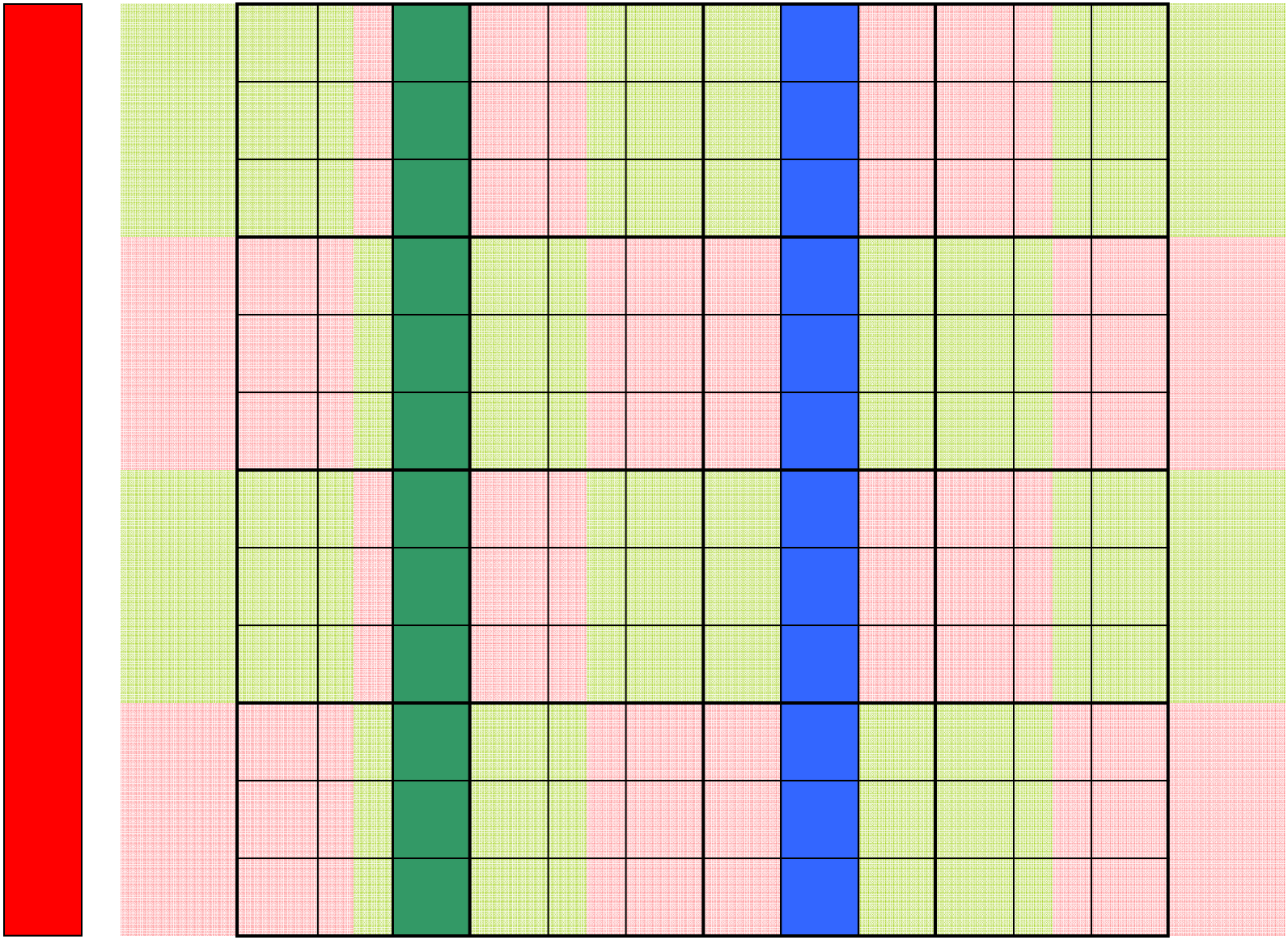


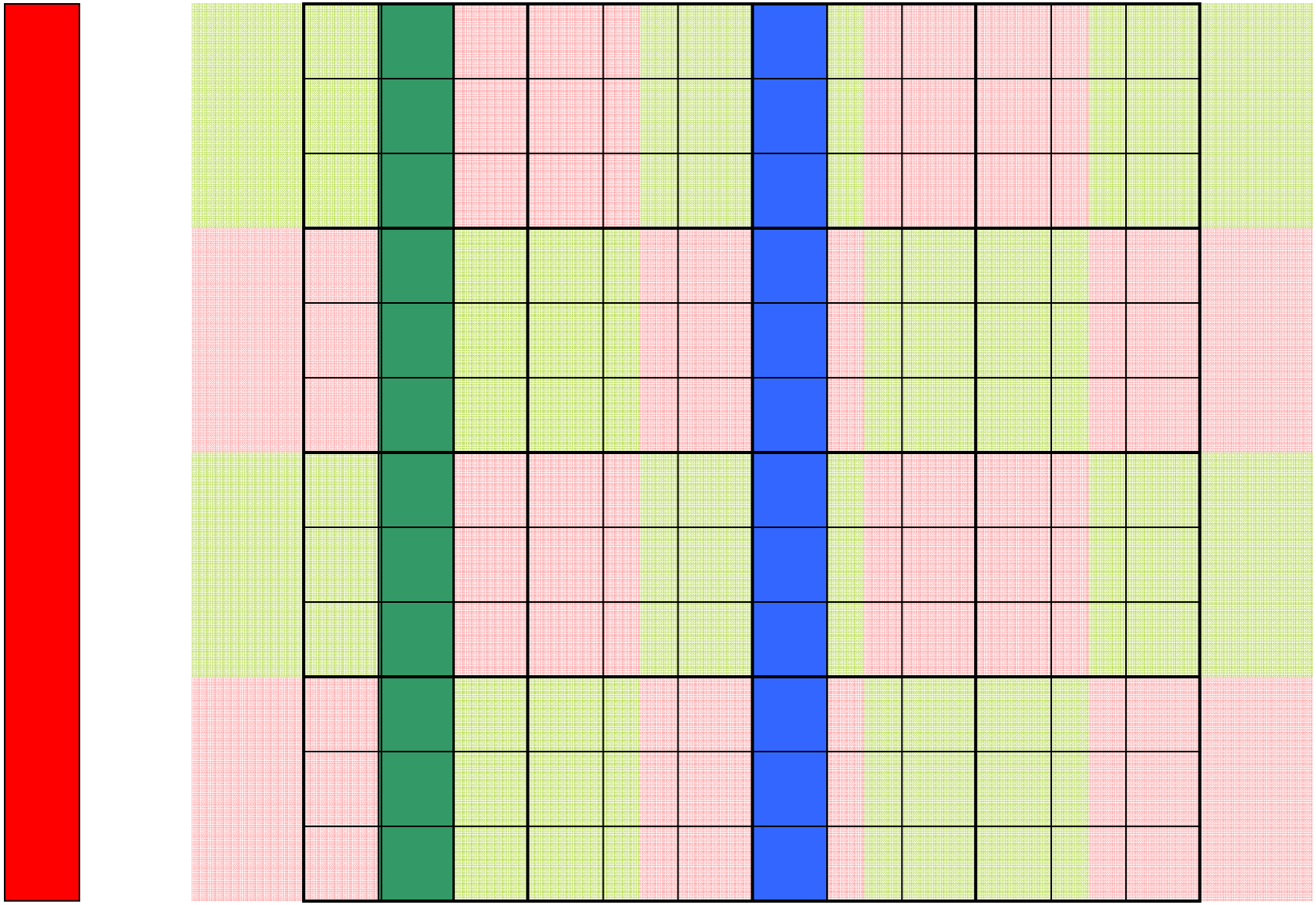


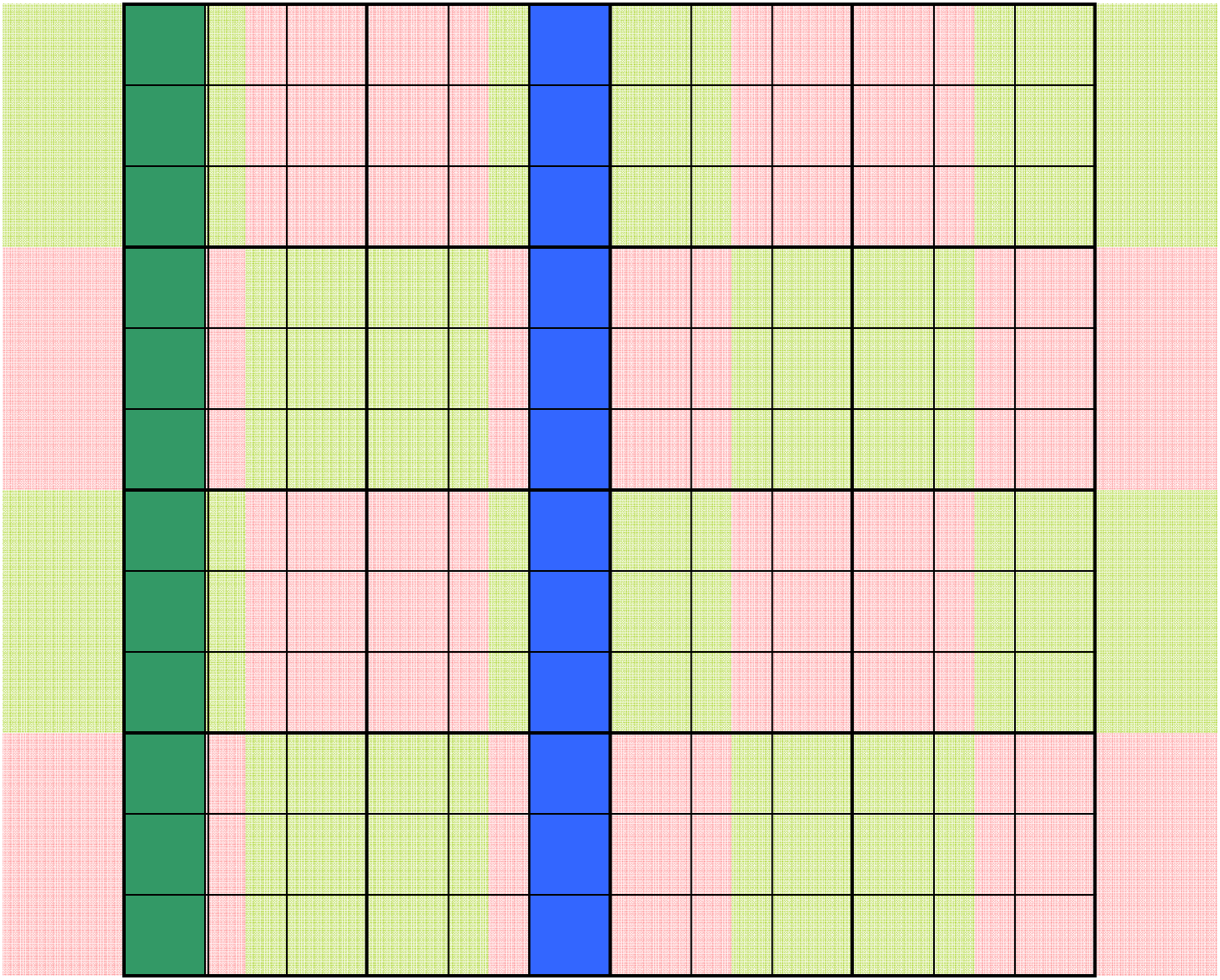


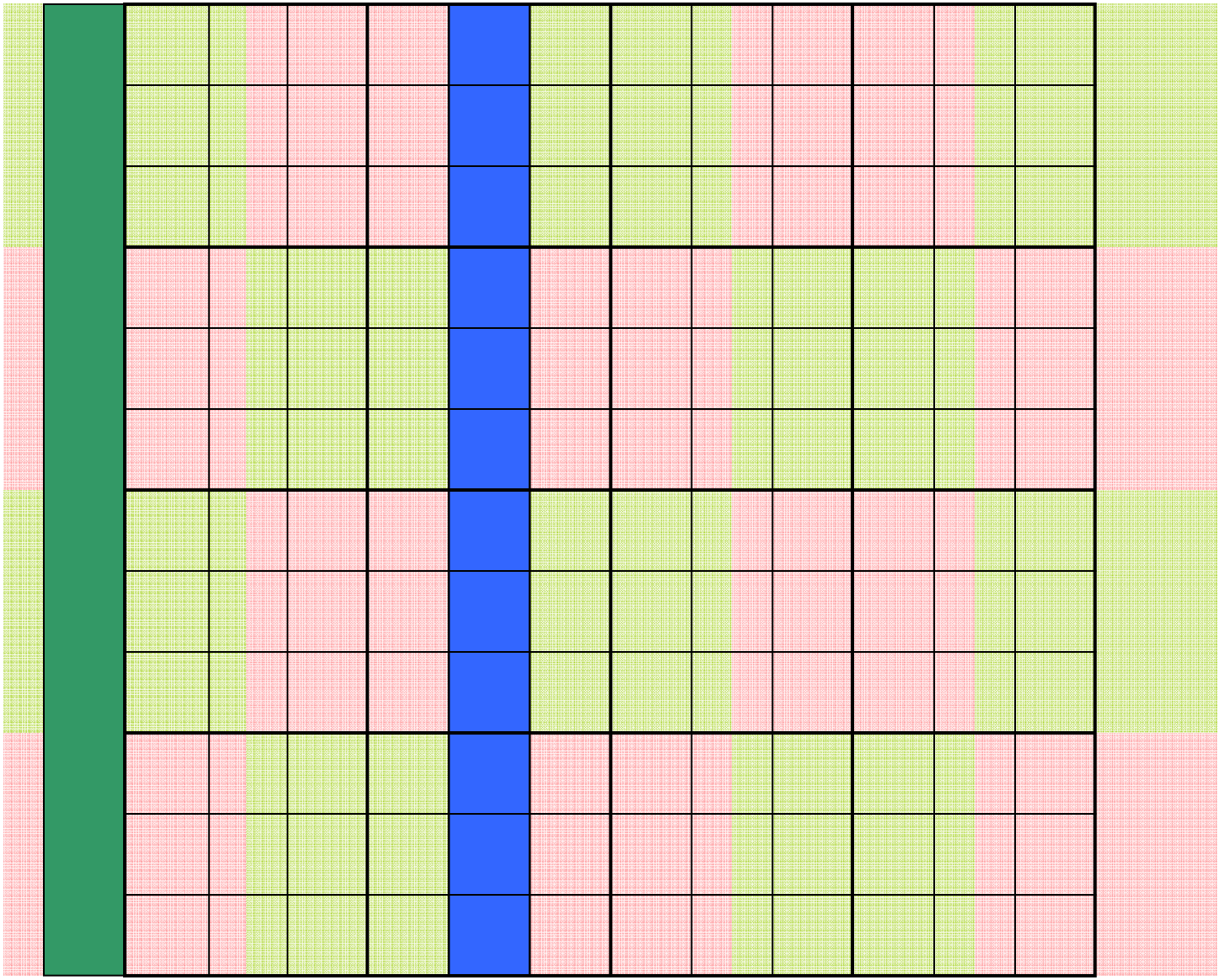


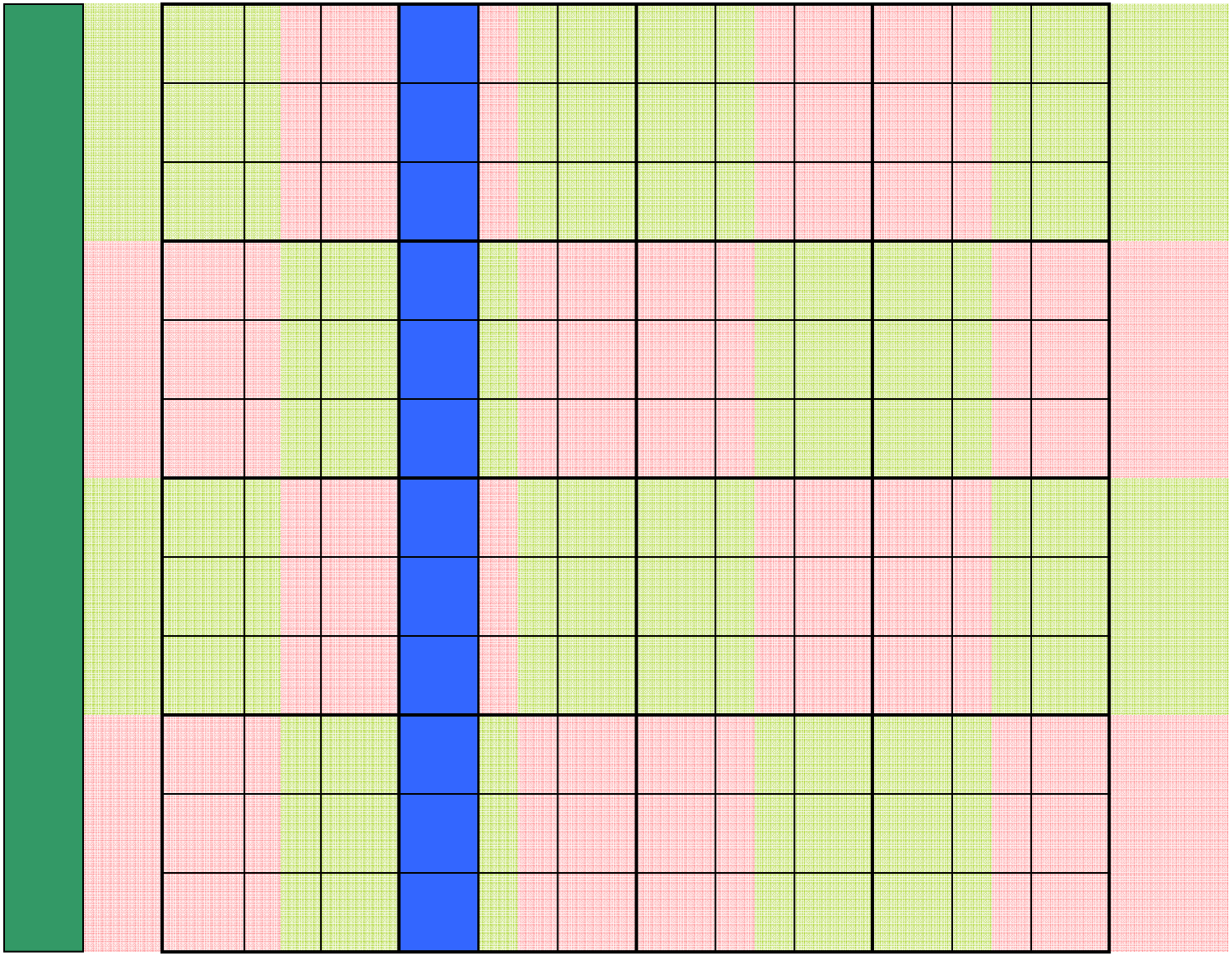


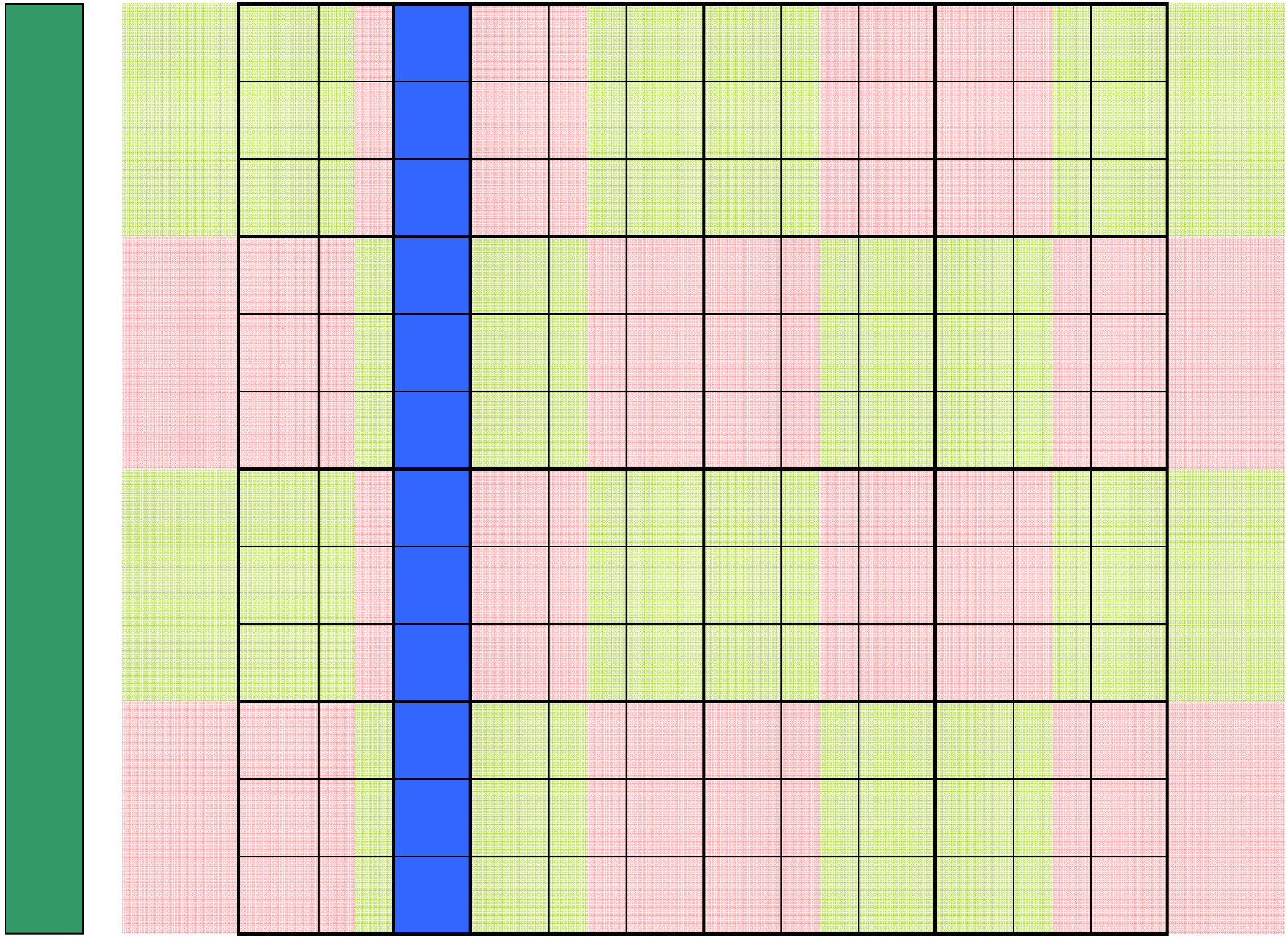


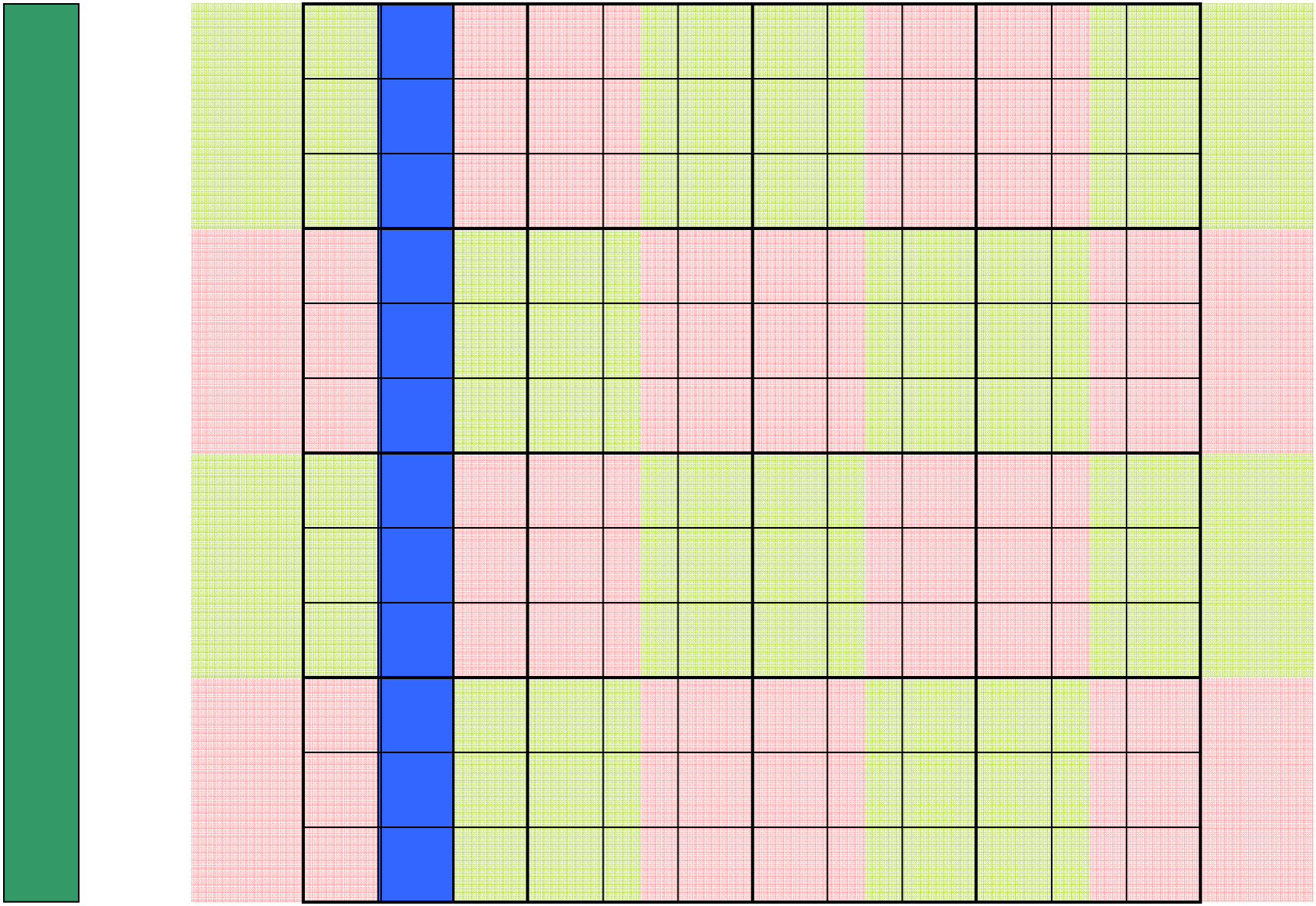


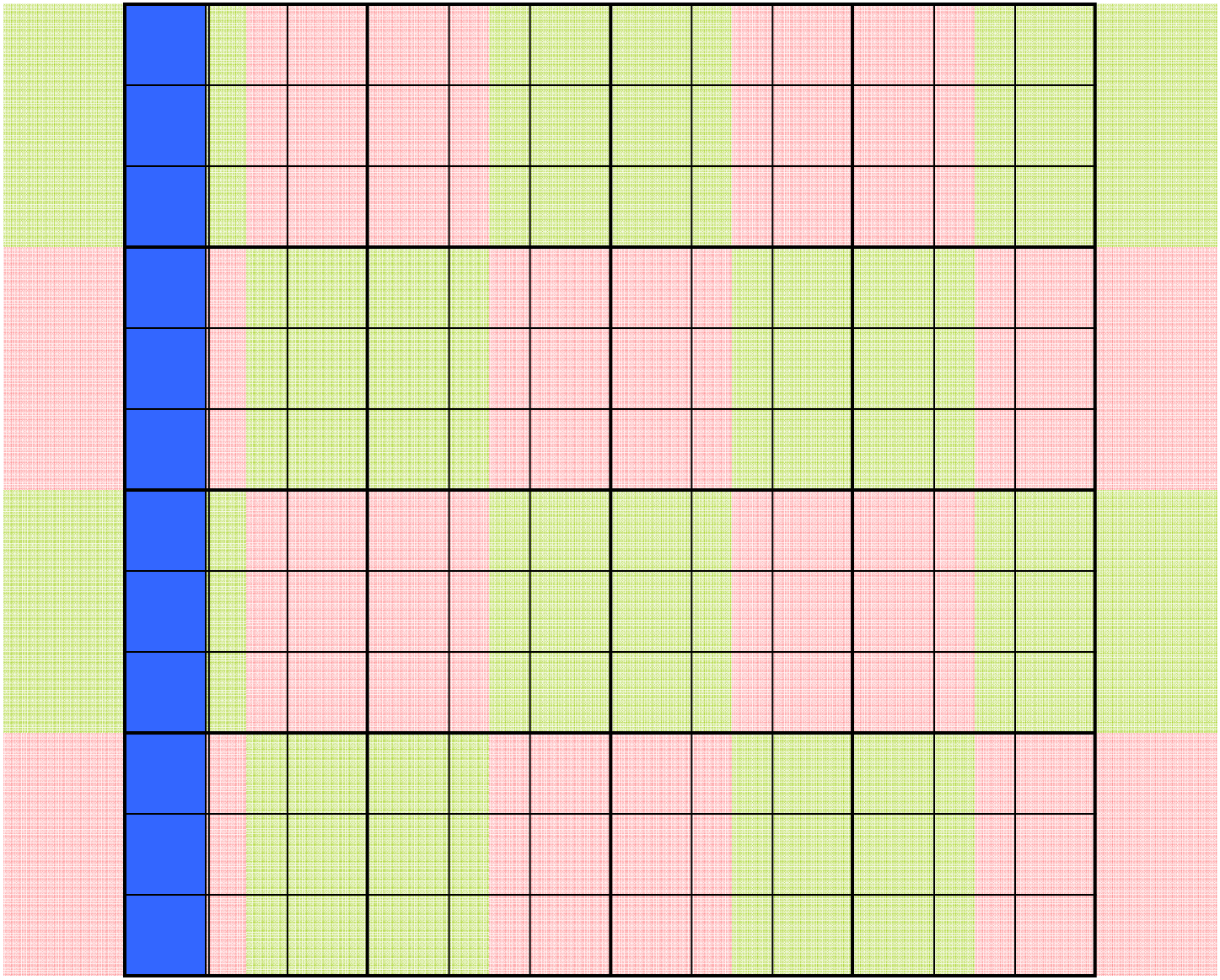


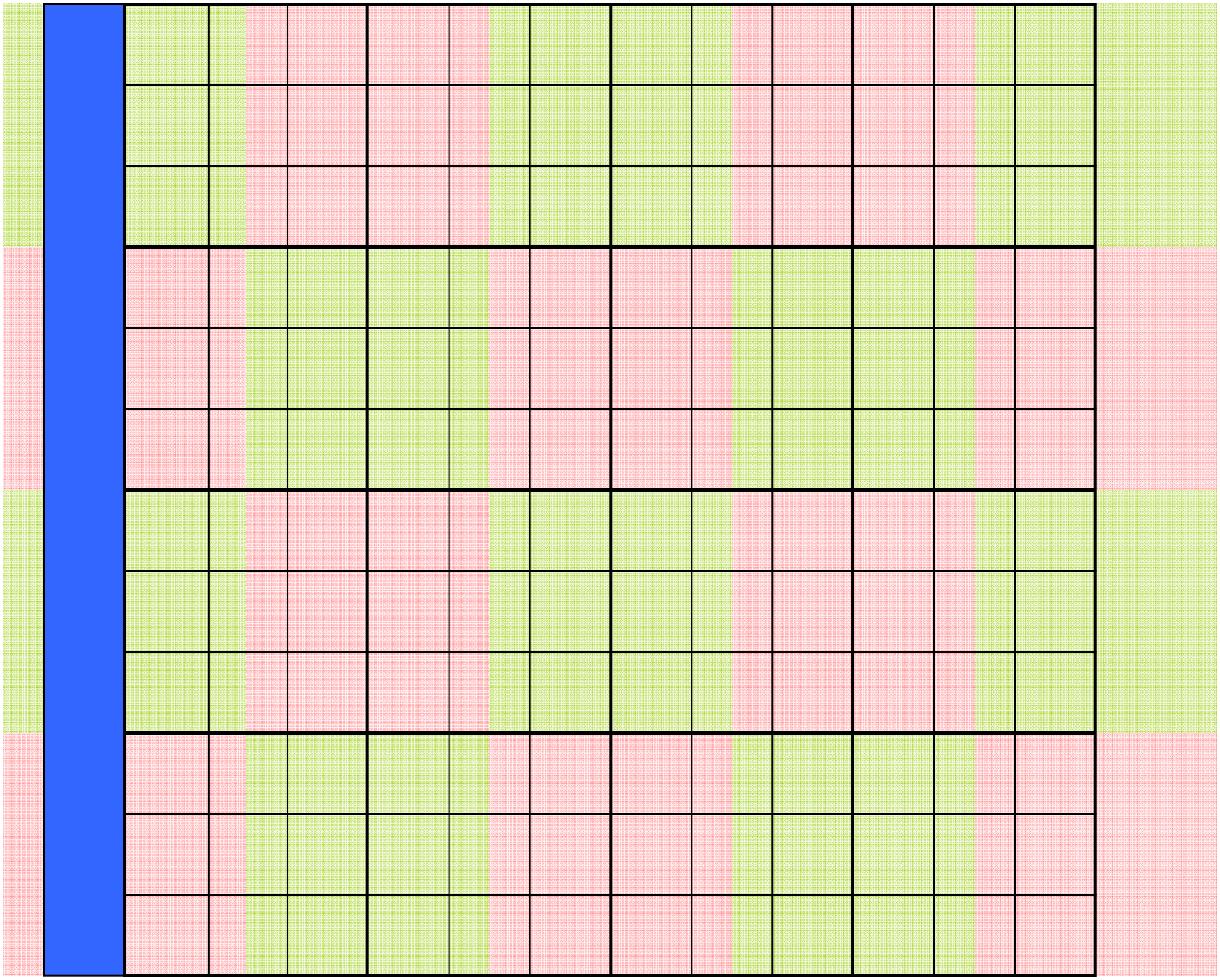


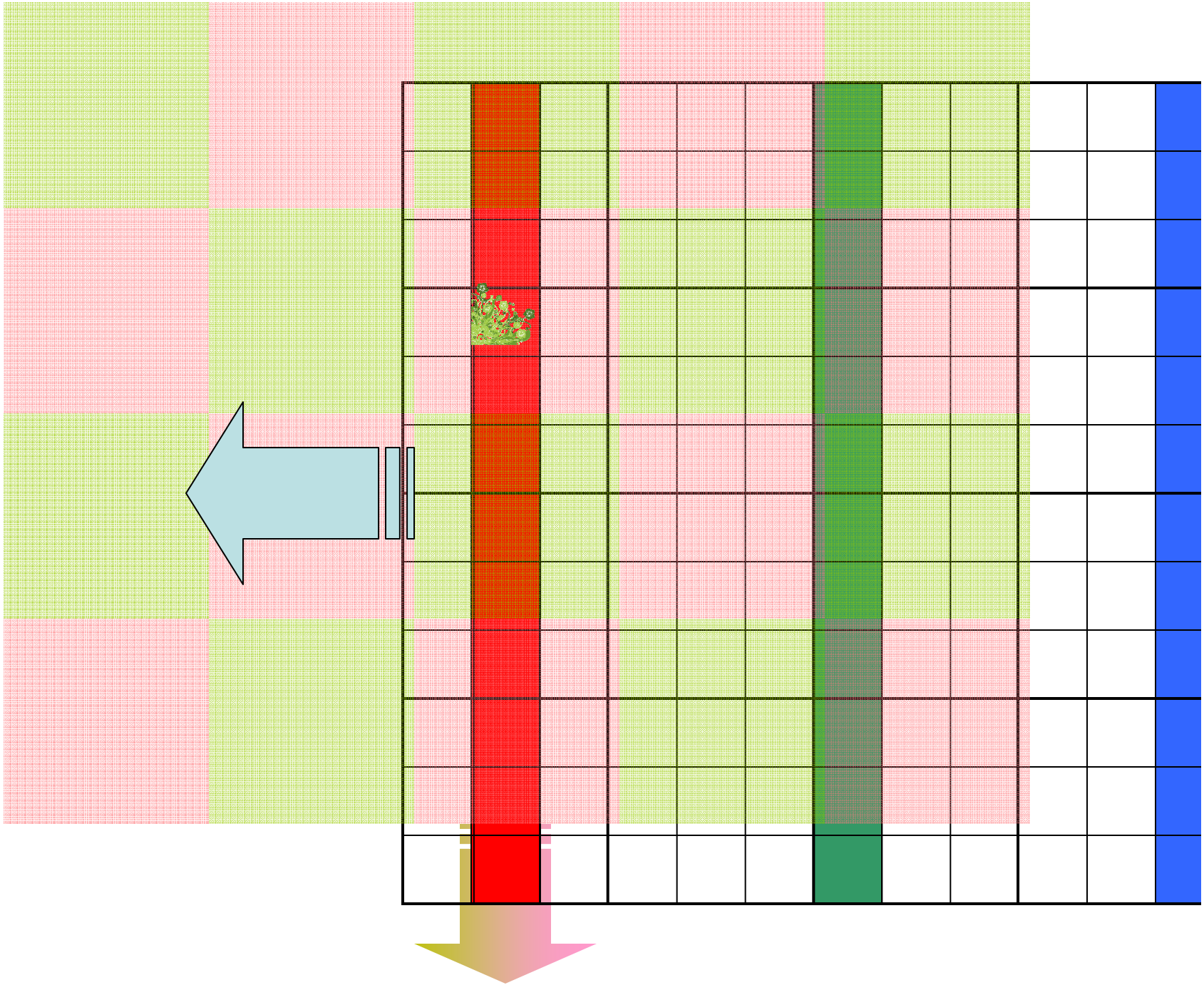


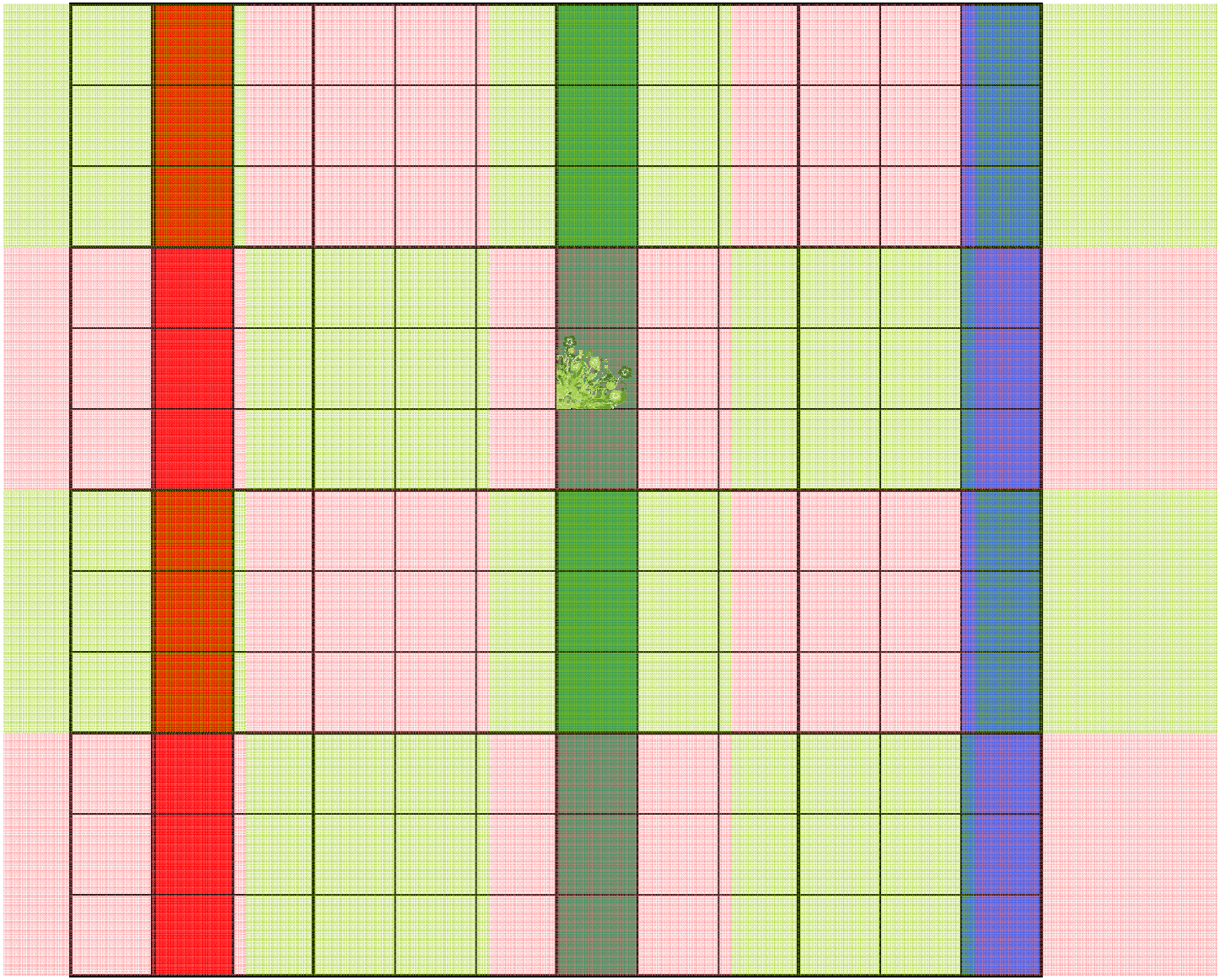


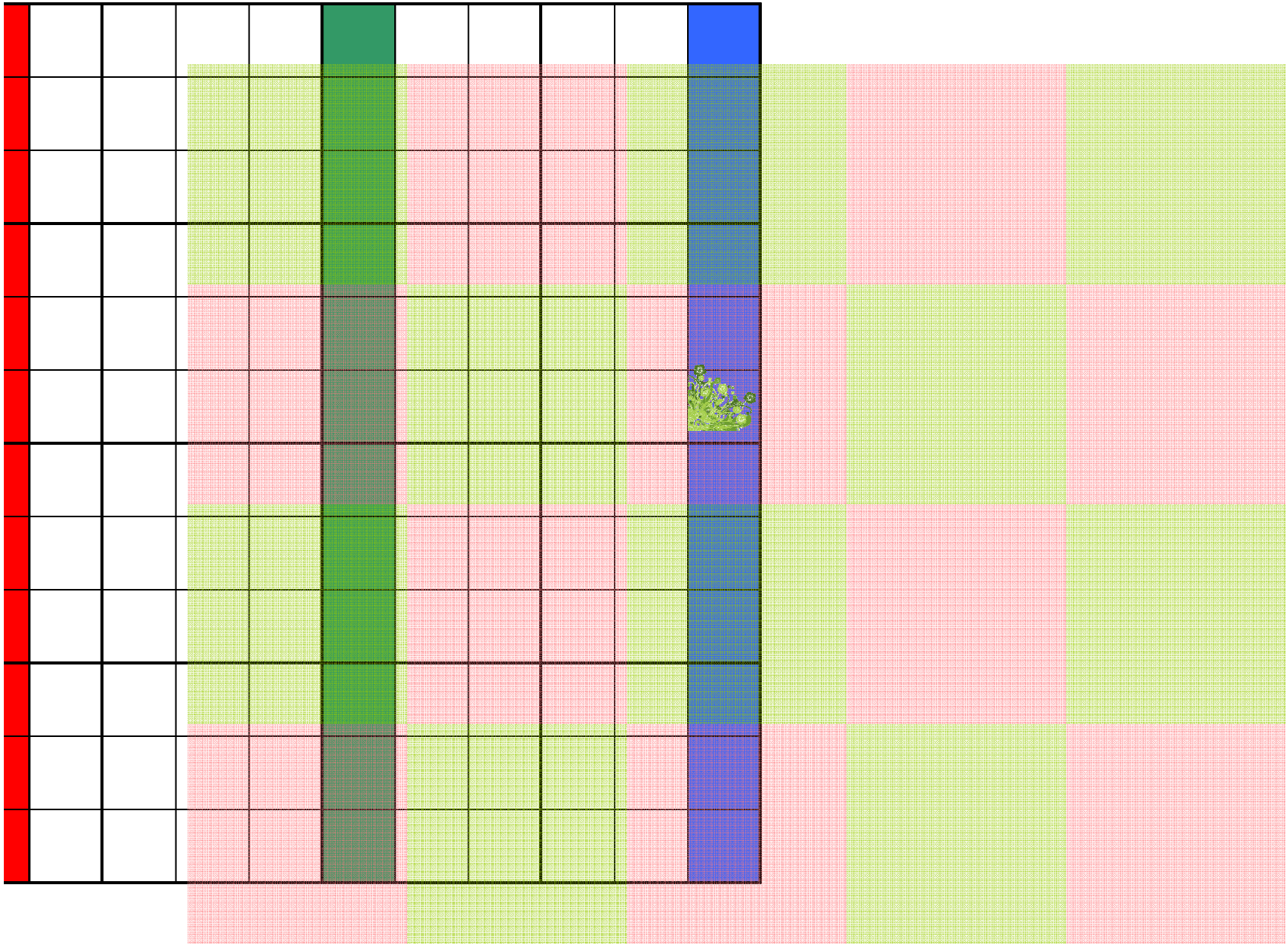


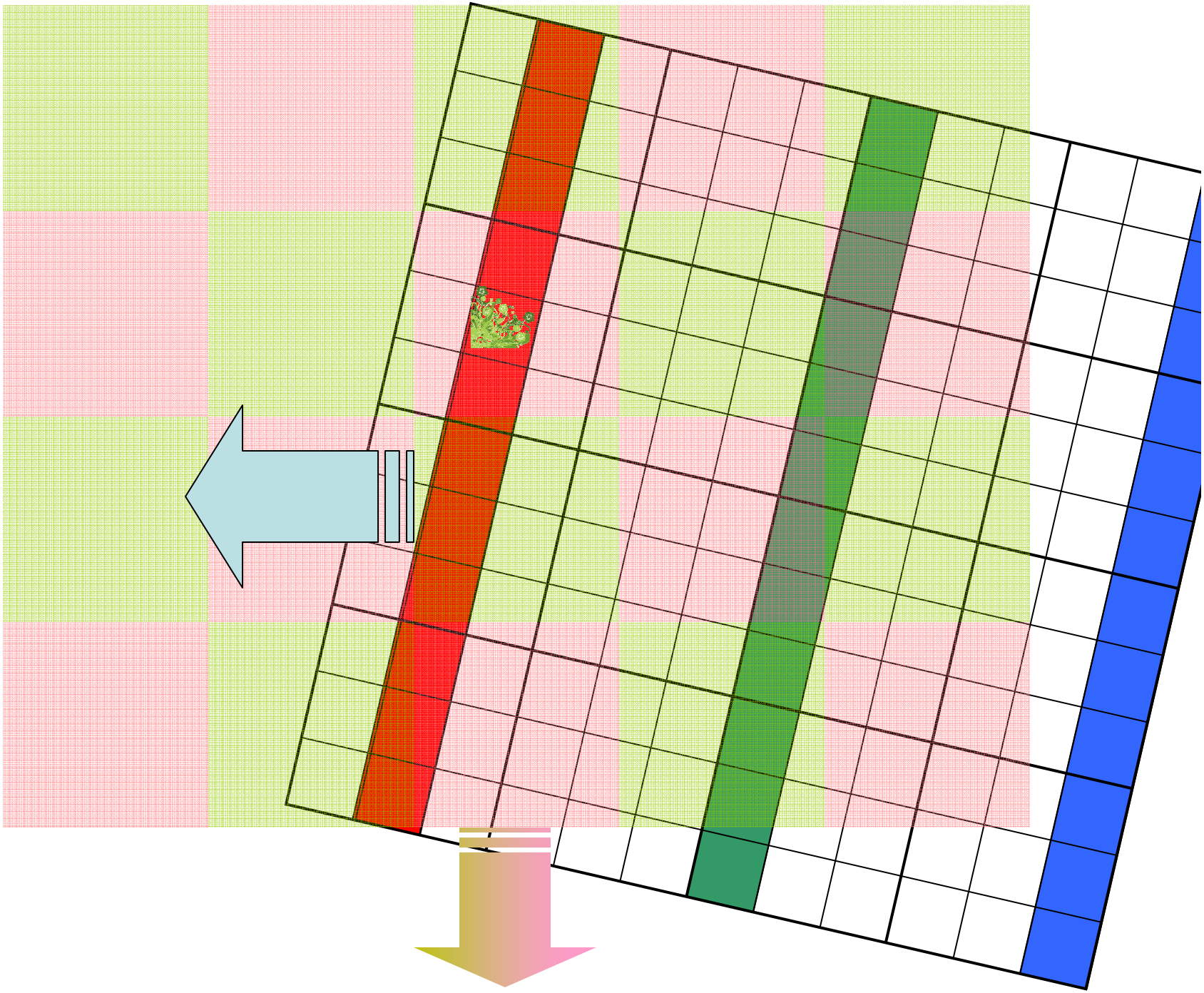


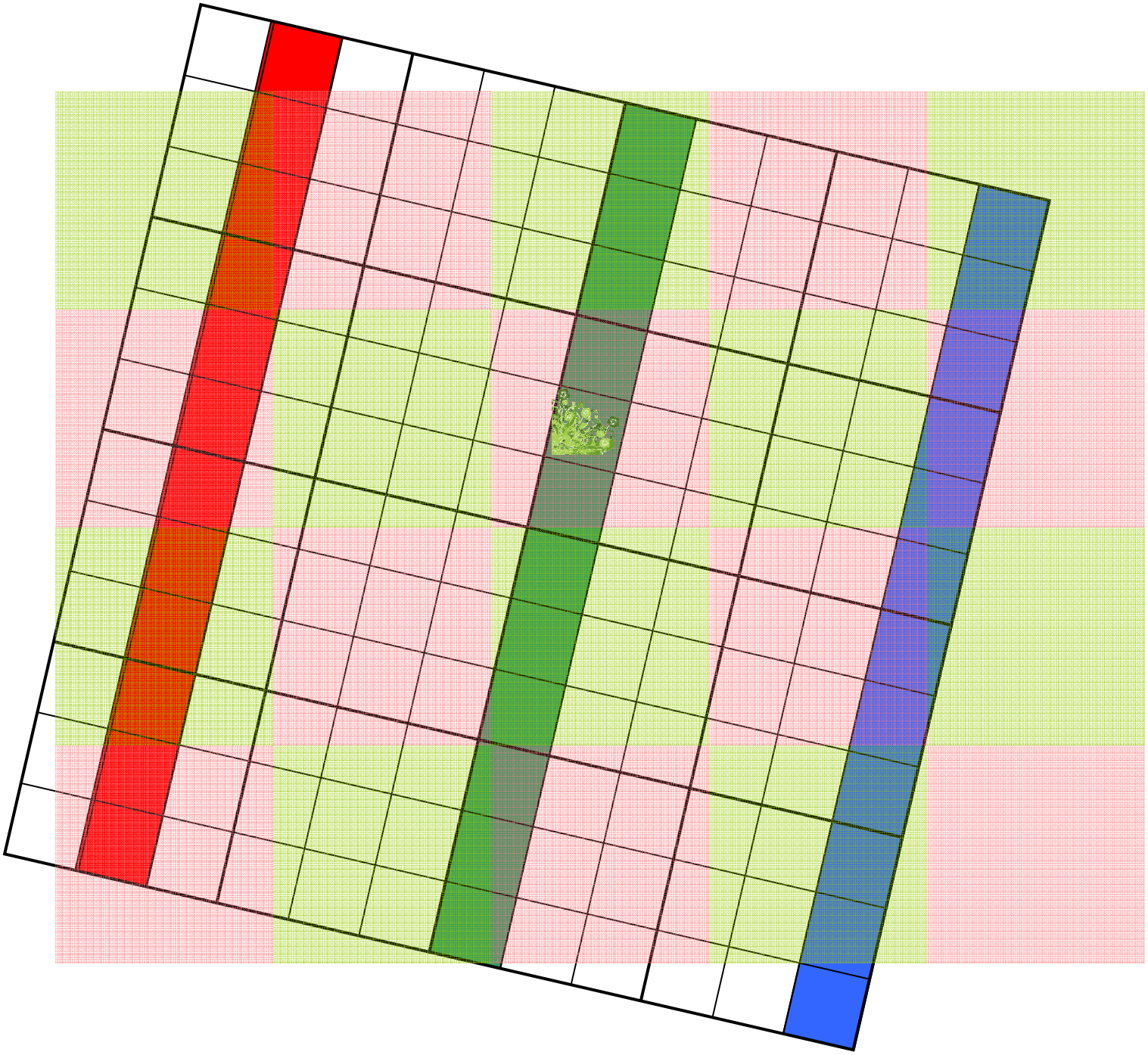


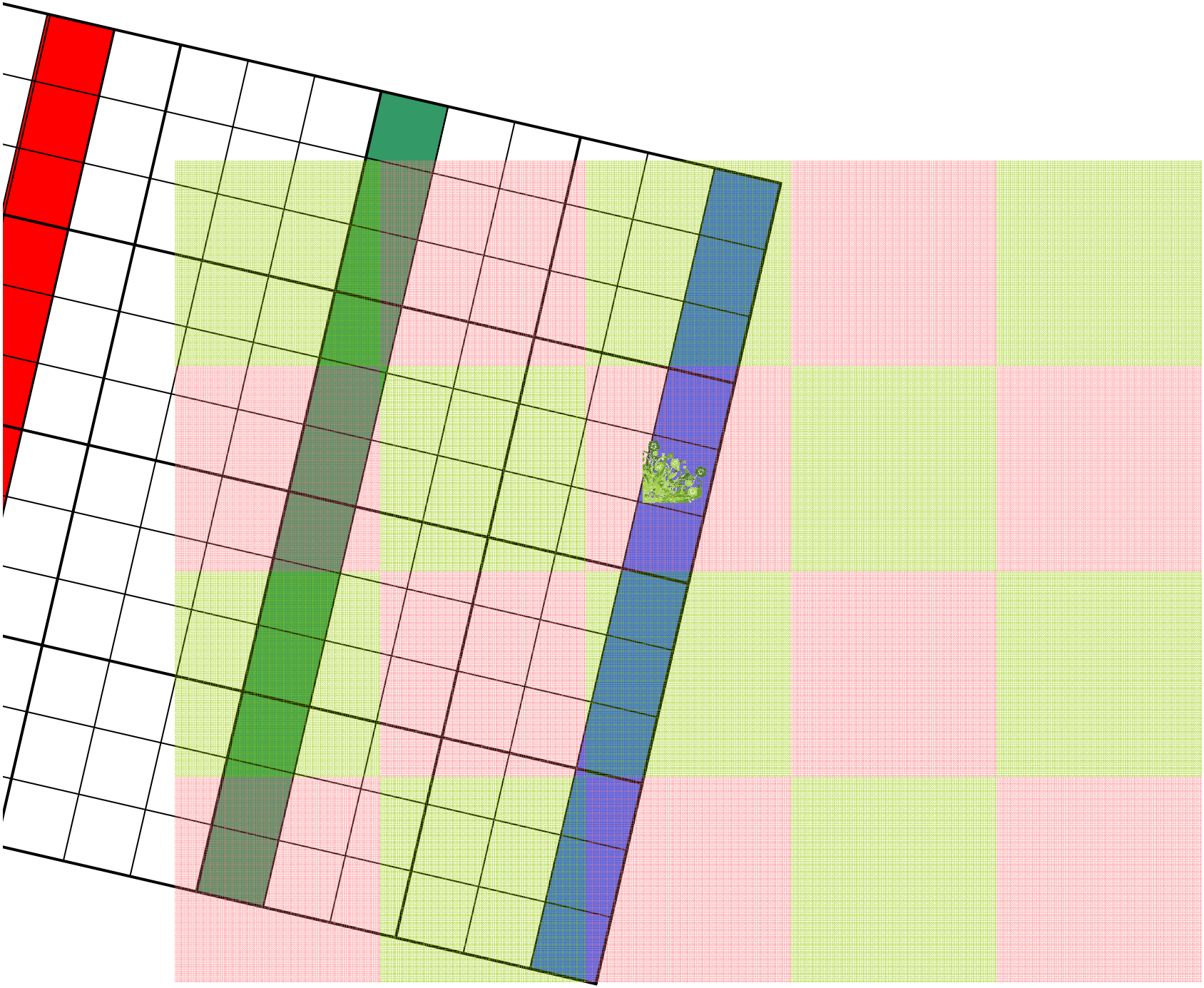












Adjusting Frame Rate to Ensure Band-to-Band Registration

$$D = N \frac{\omega(R_E + h)}{f}$$

$$D = ND_0$$

$$f = \frac{\omega(R_E + h)}{D_0}$$

$$f = f_{h=0} + \frac{\omega h}{D_0}$$

$$D_0 = 30, N \approx 230$$

$$f_{h=0} \approx 23, \omega \approx 10^{-3}$$

$$f = 23 + \frac{h}{30{,}000} \Rightarrow \Delta D \approx 10^{-2} \Delta h$$

R_o	$\equiv$	*EO − 1 orbital radius*
R_E	$\equiv$	*Earth's radius*
h	$\equiv$	*terrain altitude*
ω	$\equiv$	*angular orbital velocity*
f	$\equiv$	*EO - 1 frame rate*
D_0	$\equiv$	*GSD or pixel size/seperation*
D	$\equiv$	*within frame band seperation*
N	$\equiv$	*frames till band coincidence*

What can we do about appropriately characterizing observing systems to facilitate synergistic exploitation?

GROUP ON
EARTH OBSERVATIONS

GEOSS ADC
Architecture Workshop

Hosted by the European Commission
At the Joint Research Centre
February 4, 2008

Breakout Session 1b:
Inter-calibration Scenario
- Stephen Ungar

GROUP ON EARTH OBSERVATIONS

GEOSS Harmonization of Sensor Observations

The Global Earth Observing System of Systems (GEOSS) is to be a global, coordinated, comprehensive and sustained system of earth observing systems. The GEOSS architecture is being designed to facilitate coordinated access to data and products produced amongst all contributing systems. However, to effectively exploit information derived from disparate data sources, it is necessary to introduce consistency of content through guidelines to data providers for the appropriate characterization of the observing systems and their derived products. Ultimately, consistency can be provided through standardized “best practices”

GROUP ON
EARTH OBSERVATIONS

Workshop Session 1b

This session seeks interaction across the GEO Community to identify standards and best practices for: calibrating and validating sensors. We will start a dialog on what is needed to characterize sensor capabilities in a manner which satisfies GEO needs. Furthermore, we will explore how the Architecture Implementation Pilot can facilitate the CEOS Cal/Val Portal, as well as how the Cal/Val Portal can contribute to meeting the objectives AIP.

GROUP ON EARTH OBSERVATIONS

Coordination with GEO and related tasks:

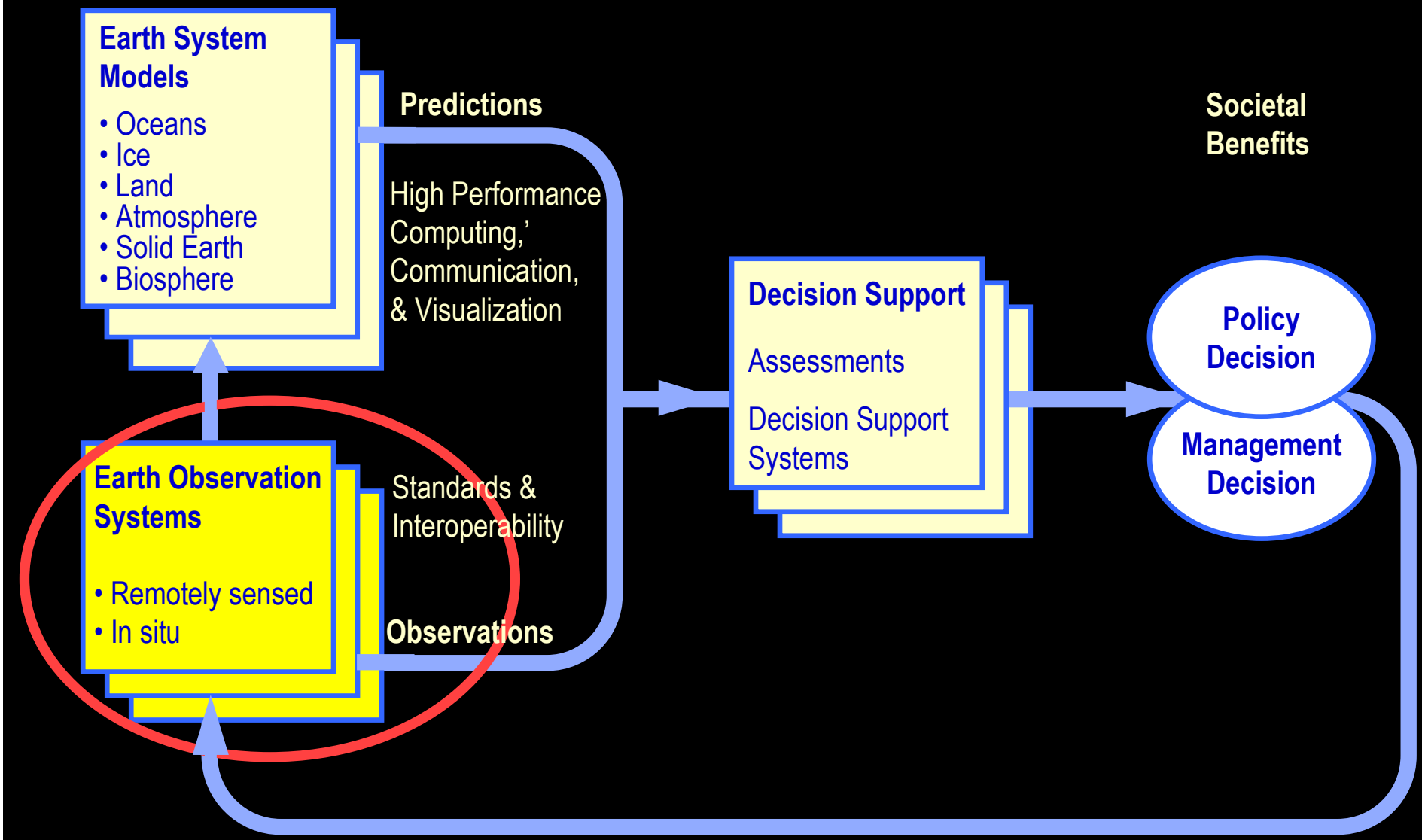
- DA-06-02 (Data quality assurance strategy for space-based and related in-situ observations)
- CL-06-02 (Key Climate Data from Satellite Systems)
- DA-07-04 (Sensor Web Enablement for In-Situ Observing Network Facilitation)
- DA-07-05 (Higher Level Data Product Tools)
- WE-06-02 (Space-based Global Observing System for Weather)
- **CEOS WGCV (Committee on Earth Observation Satellites, Working Group on Calibration and Validation)**

GROUP ON EARTH OBSERVATIONS

Refining the GEO Data Quality Framework

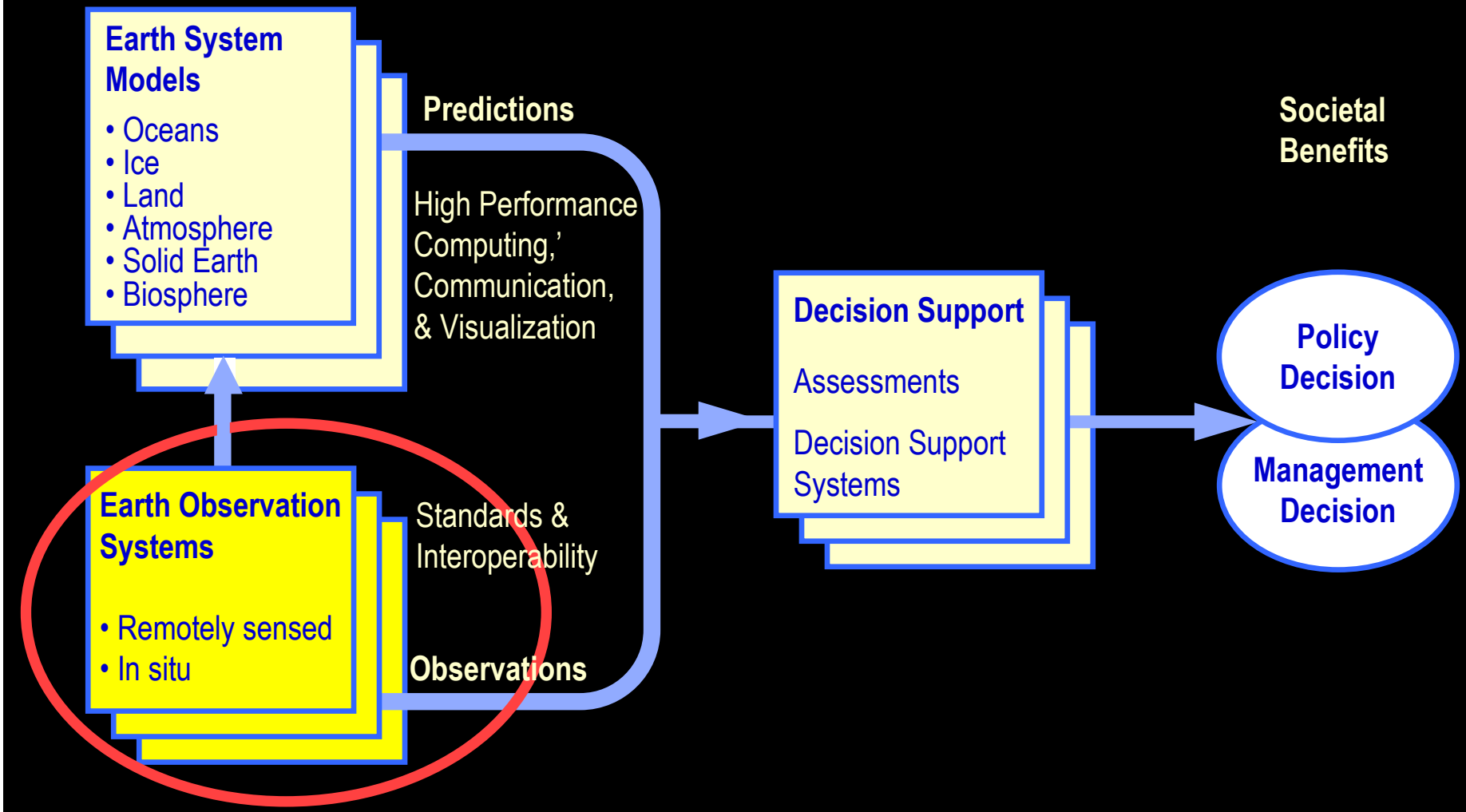
Over the past three years, the CEOS WGCV, in conjunction with participants in DA-06-02, has developed a Data Quality Framework (DQF) for GEO. The CEOS Cal/Val Portal, a prototyping activity, designed to test and refine the guidelines presented in the DQF, has been instituted under ESA sponsorship. This activity is an extension of the historic (and extensive) participation in the WGISS Test Facility (WTF) by WGCV. This task was the principle topic of the GEO-CEOS Quality Assurance Workshop held at the GEO Secretariat in Geneva last October. A follow-up workshop is to occur at NIST in Gaithersburg, Maryland during the first week of May. A scenario involving the use of a common Antarctic Cal/Val site (Dome C) for selected optical and microwave observing systems from several national agencies, will be introduced at the Joint WGCV/WGISS Plenary to be held in Sanya China during the last week of February

GEOSS Architecture

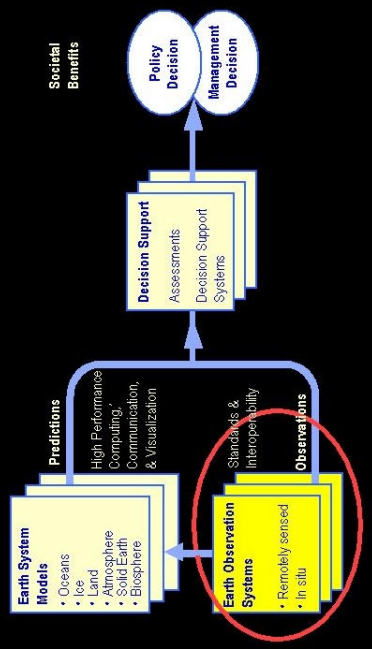


From: The Architecture of GEOSS (GEO4DOC 4.1 [2]; April 5, 2004)

GEOSS Information Flow



GEOSS Information Architecture



Societal benefits

Decisions
policy
management

Recommendations

Decision support:
Assessments and Systems

Predictions

Earth System Models:
Atmosphere, Oceans, Ice, Land/Biosphere

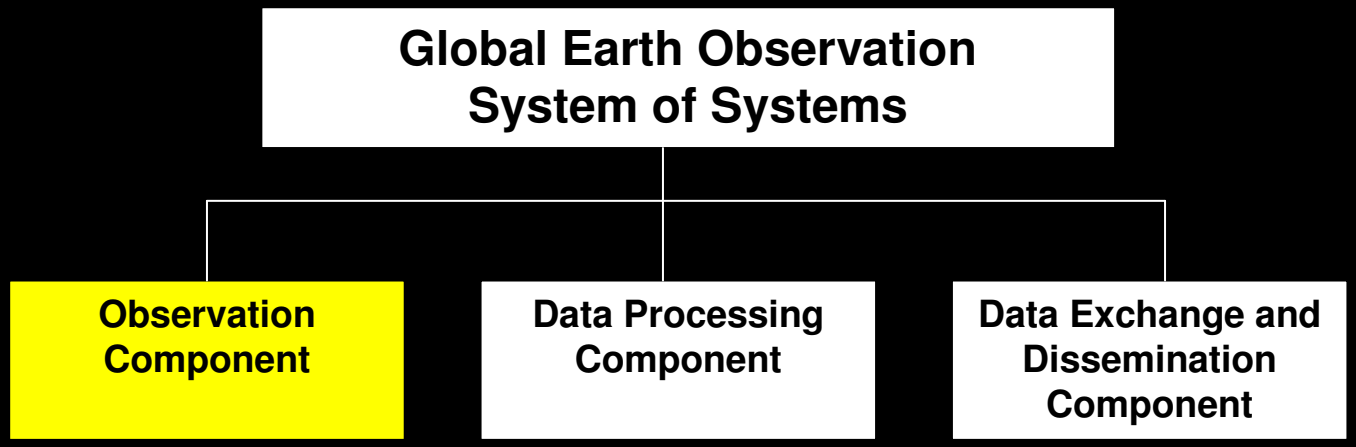
Data,
Standards and Interoperability

Earth Observation Systems
Remote Sensing observations *In situ* surveys and measurements

The WGCV GEOSS Information Pyramid

Cal/Val *strengthens the base* as shown in the following slides

Components of GEOSS Architecture

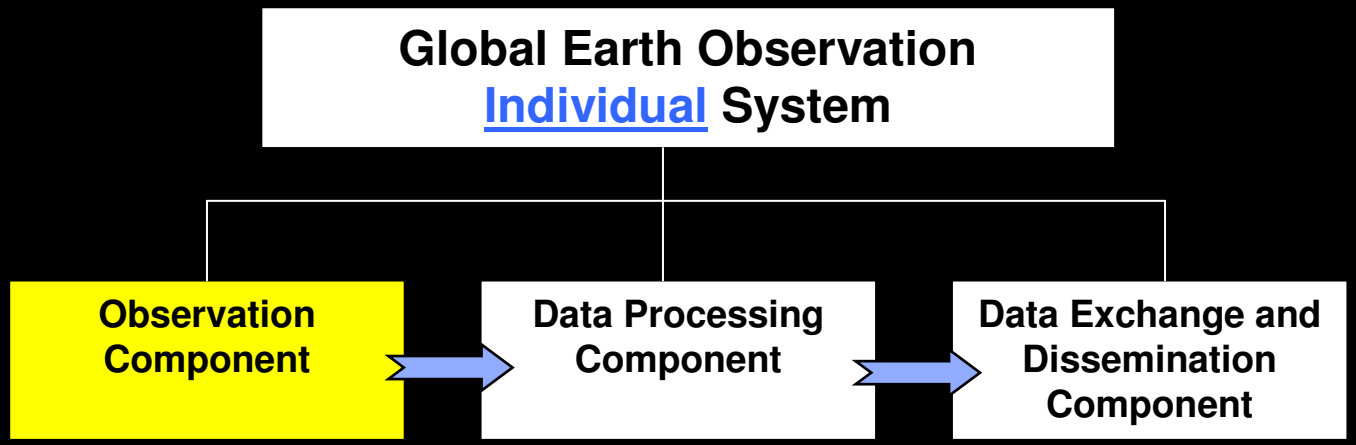


GEOSS architecture builds incrementally on existing systems to create a distributed system of systems, incorporating:

- an observation component
- a data processing and archiving component
- a data exchange and dissemination component

From: The Architecture of GEOSS (Global Earth Observation System of Systems); GEO4DOC 4.1 (2); 4.5.2004

Components of GEOSS Architecture



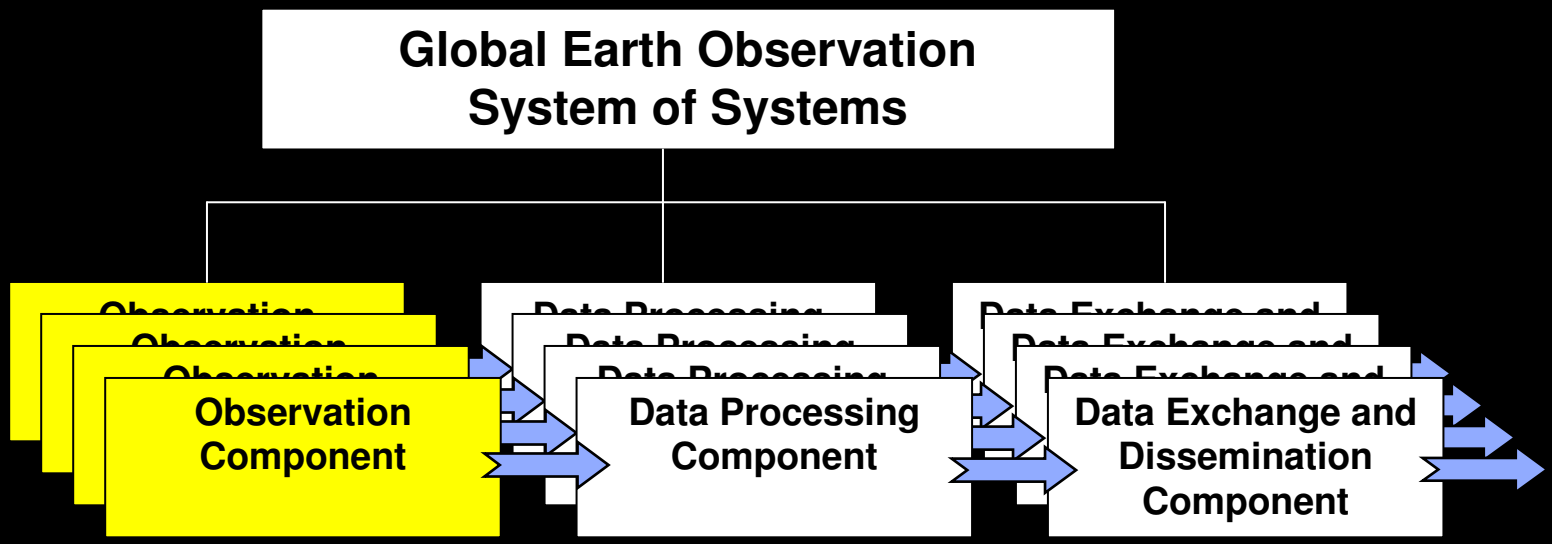
GEOSS architecture builds incrementally on existing systems to create a distributed system of systems. WGCV activities contribute to the following GEOSS components:

- Observation component
- Data processing and archiving component

To ensure:

- data and products interoperability, exchange and dissemination

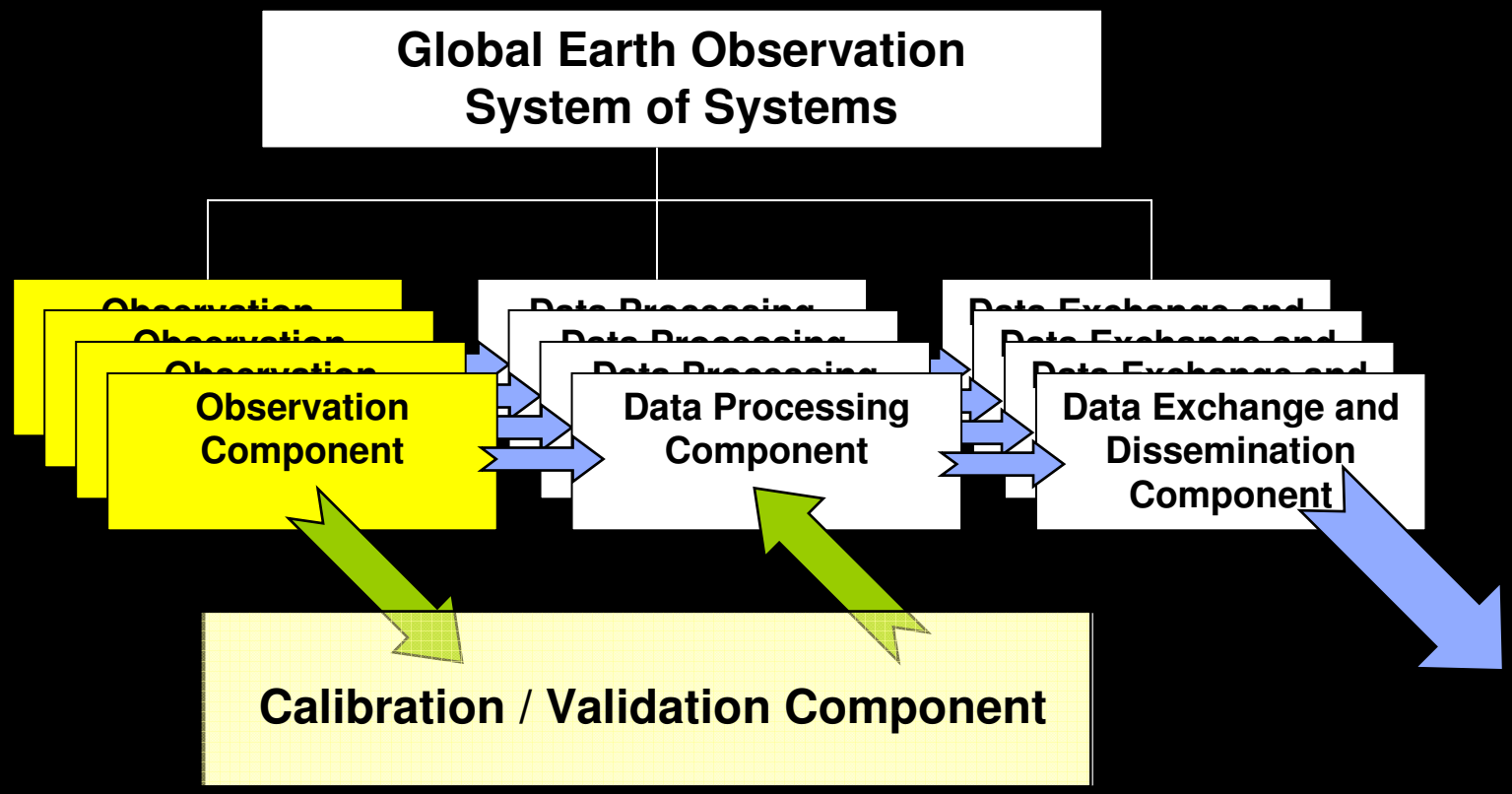
Inadequate Cal/Val in GEOSS Architecture



What's missing in this scenario?

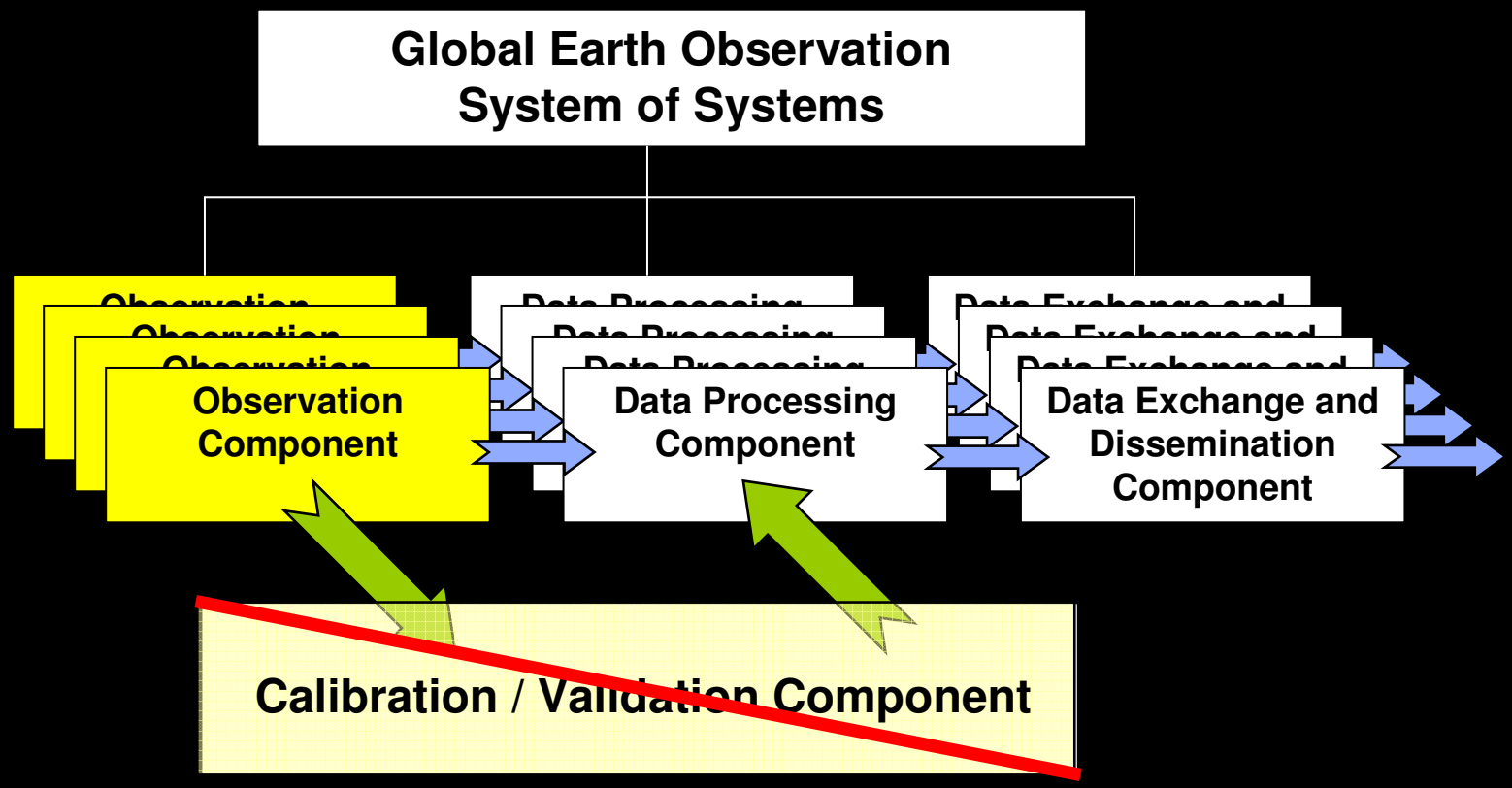
A simplistic view of a System of Systems results in the need to deal with potentially disparate information forcing policy makers to "choose" their outcomes.

WGCV contribution to GEOSS Architecture



Role of WGCV in a true System of Systems where the operating space must cut across individual Systems to provide <u>integrated</u> data for decision models

Inadequate Cal/Val in GEOSS Architecture



Inadequate integration of data sources can lead to disparate model outcomes, introducing uncertainty into the decision process

Establishing Calibration and Validation guidelines is a necessary ingredient in achieving Data Interoperability

WGCV proposes to establish Calibration and Validation guidelines, to ensure *effective* interoperability of GEOSS member satellite data sources, based on the current space agencies collaboration agreements, common formats and standards.

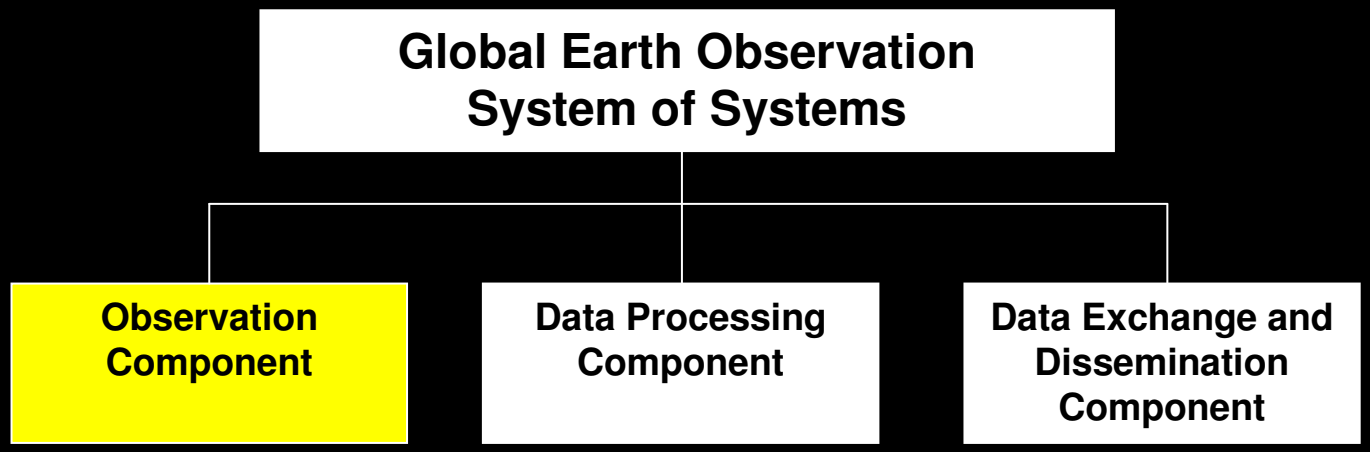
- **WGCV proposes that all GEOSS partners participate in the establishment of the following common practices:**
  - Document the methodologies used to derive and further process satellite measurements.
  - Create and maintain, in conjunction with WGISS, an internet-accessible information database containing, on an instrument or satellite basis, links to all instrument characteristics needed for insuring inter-operability.
  - Provide/publish Cal/Val reference methods in a readily accessible form.

These activities will ensure that the various data are integrable.

CEOS
Committee on Earth Observation Systems

Elaboration

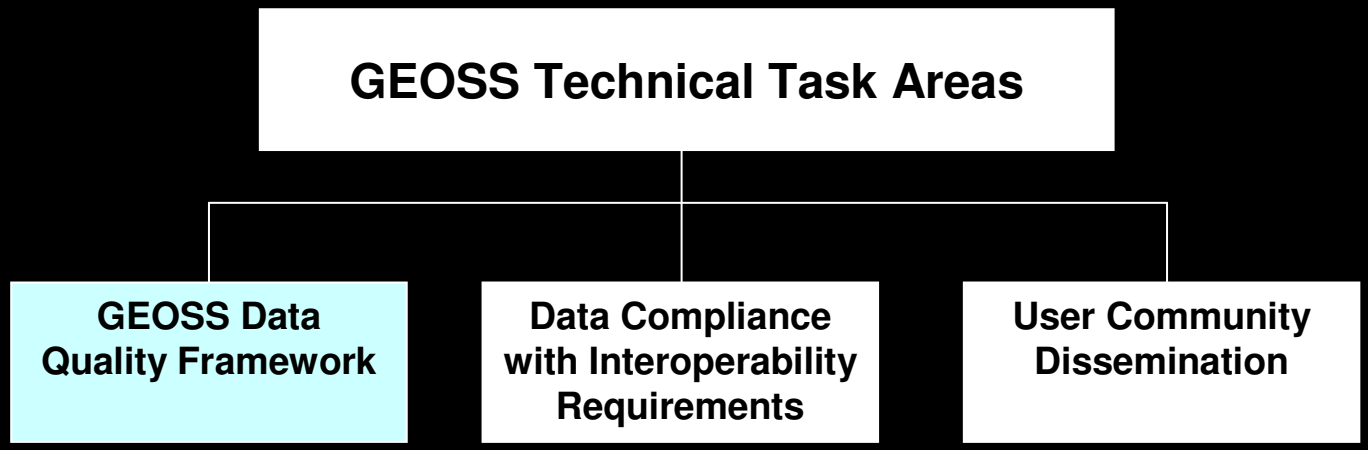
Components of GEOSS **Architecture**



The high level GEOSS **architecture** is a componentization of a structure required to accomplish the GEOSS objectives which is consistent with the structure of most contemporary Earth Observing data systems. There is a need to define the components of GEOSS **functionality** required to enable the fulfillment of GEOSS objectives through this architecture.

Further elaboration

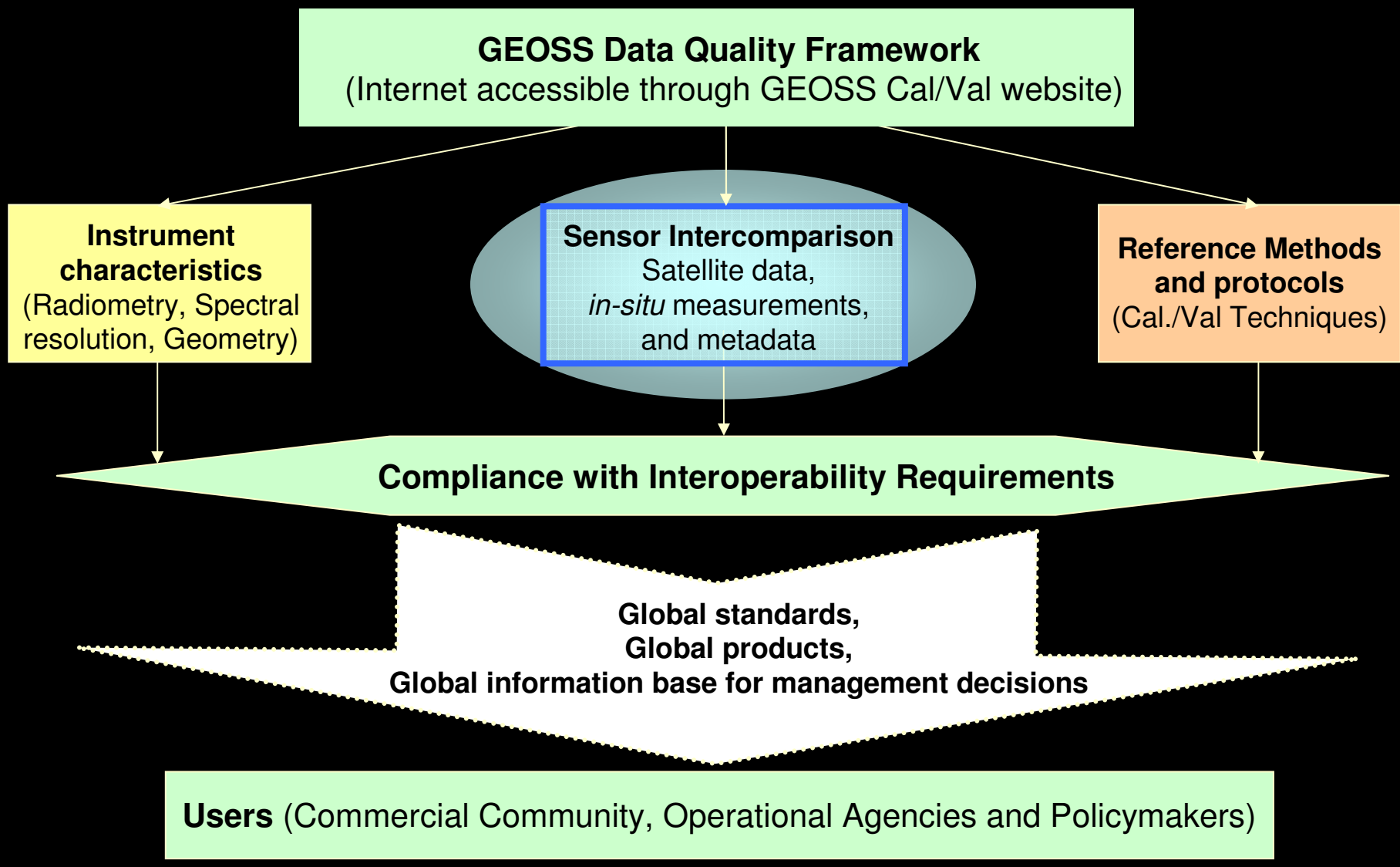
Components of GEOSS **Functionality**



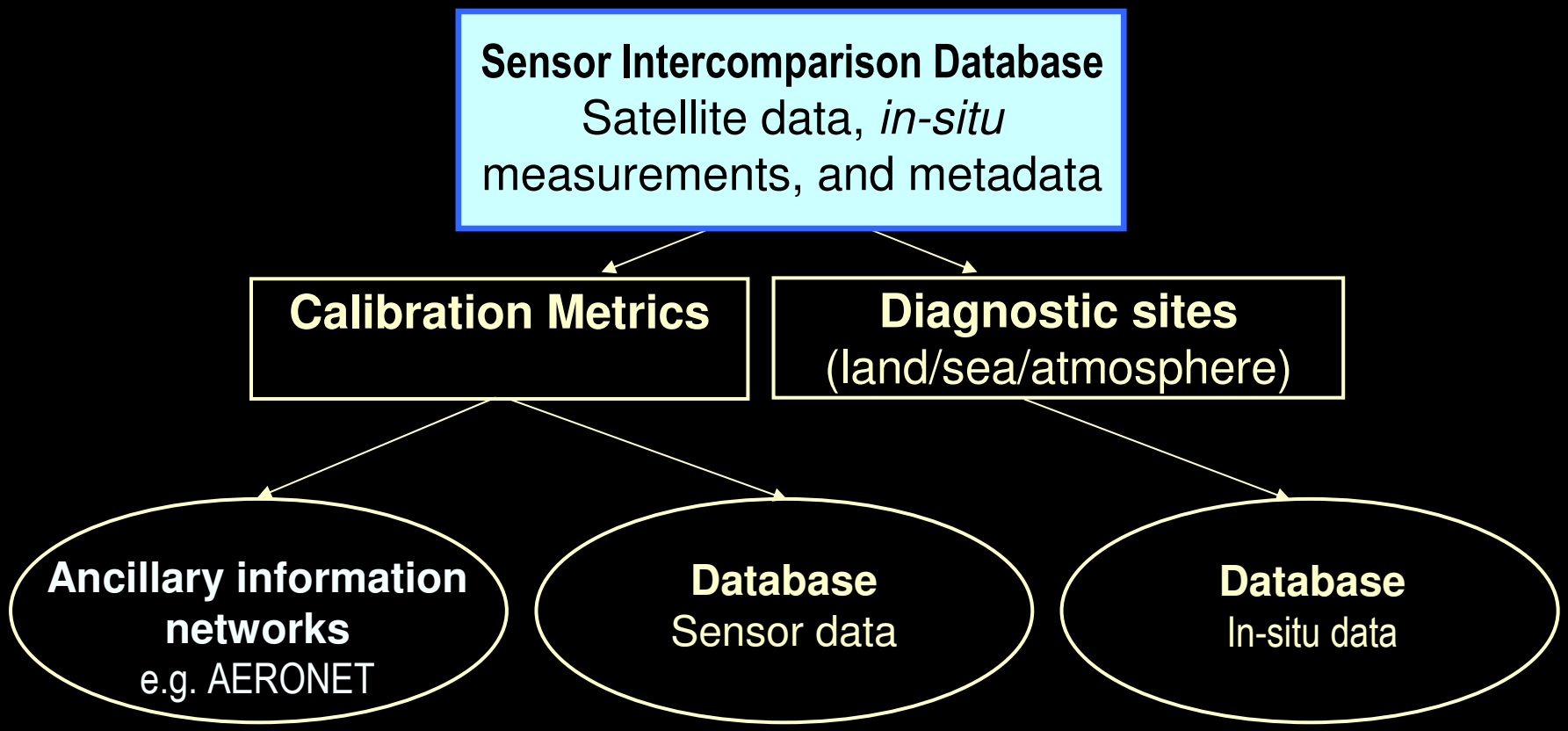
The high level GEOSS **functionality** componentization introduces a structure whch ensures accomplishment of required GEOSS objectives within the proposed GEOSS **architecture**. There is a need to specify **functionality** for the components of GEOSS **architecture** to enable the fulfillment of GEOSS objectives through this architecture.

These components are designed to ensure data integrability and interoperability.

WGCV Proposal



WGCV Proposal GEOSS Cal/Val Data Framework



CEOS
Committee on Earth Observation Systems

Road Map for proposed activities addressing task GEO DA-06-02

	2006	2007	2008	2009	2010	2011	2012
Phase 1	Planning *(develop strategies, determine elements/activities/ tasks)*						
Phase 2		Implementation *(develop and/or establish a set of commonly accepted shared technical tools and inter-agencies collaborations and agreements)*					
Phase 3					Delivery (present and explain to the community and distribute to CEOS member agencies)		

Conclusion

The approach outlined in the WGCV White Paper entitled “Data Quality Guidelines for Satellite Sensor Observations Relevant to GEOSS: Calibration and Validation Issues” has been crafted to ensure the quality assessment of space-borne instrument data in the context of a service driven global operational Earth observation remote sensing system.

This approach exploits ongoing work and available expertise among the CEOS working group members, and provides a mechanism for further development over the 10-year timescale of the GEOSS Implementation Plan.