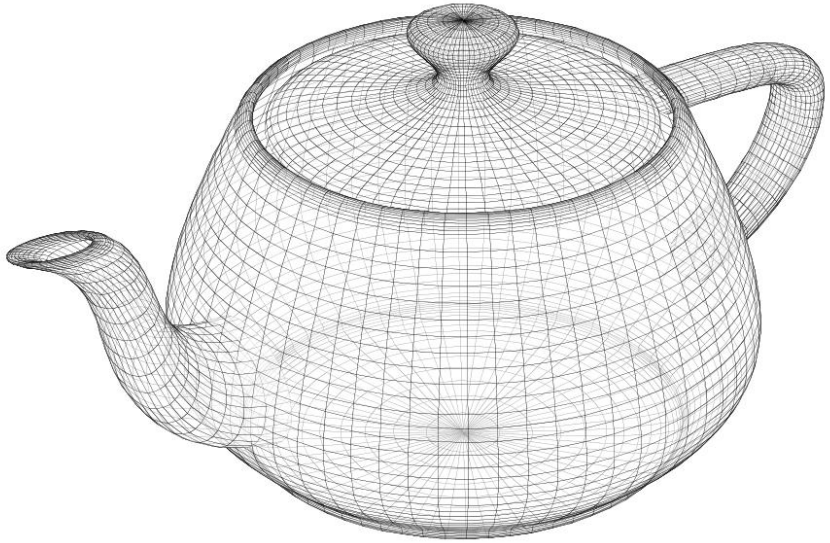

Noise-Based Textures: Sums of Noise Functions

Production Computer Graphics

Eric Shaffer

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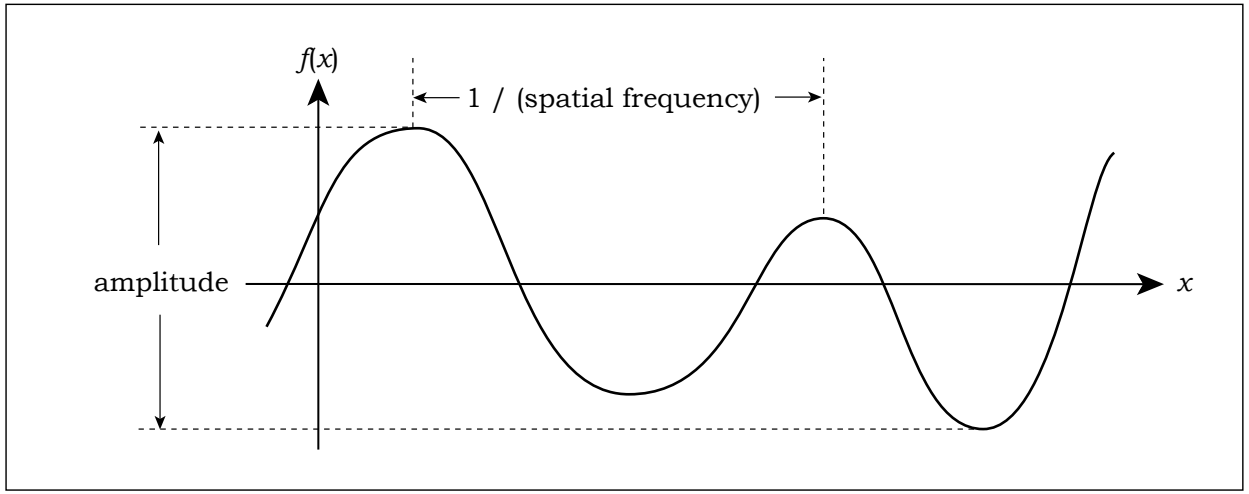
Altering Noise Functions

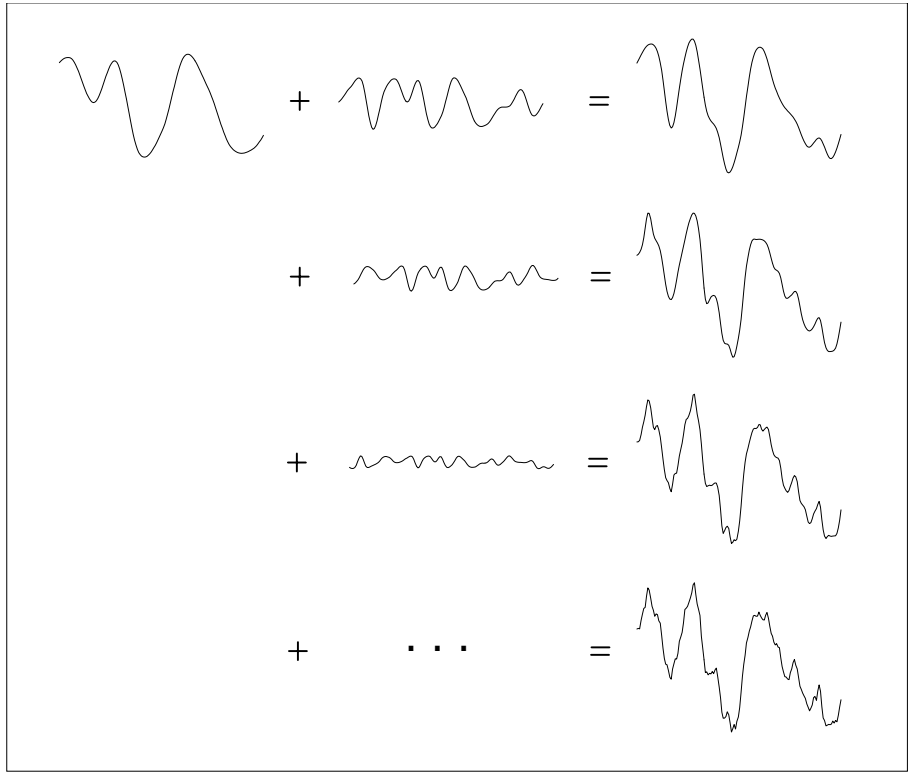
Can alter the functions by summing them

- Use different amplitudes and frequencies
- Spatial frequency describes how quickly function varies with position
- Band-limited → finite max spatial frequency



Fractal Sum

Create a new function summing shifted noise functions



$$fractal\_sum = noise(p) + \frac{1}{2}noise(2 * p) + \frac{1}{4}noise(4 * p) + ...$$

Fractal Sum

$$fractal\_sum(p) = \sum_{j=0}^{n-1} \frac{noise(2^j p)}{2^j}$$

$$fractal\_sum(p) = \frac{noise(p)}{1} + \frac{noise(2p)}{2} + \frac{noise(4p)}{4} + \ldots$$

$$fractal\_sum = \left[2\left(1 - \left|\frac{1}{2}\right|^{n-1}\right) \quad 2\left(1 - \left|\frac{1}{2}\right|^{n-1}\right) \right]$$

- Create a new function summing shifted noise functions
- Each successive term has
  - half the amplitude
  - twice the spatial frequency
- Terms that differ by a factor of 2 are called *octaves*
- Can scale value to lie in [0,1]

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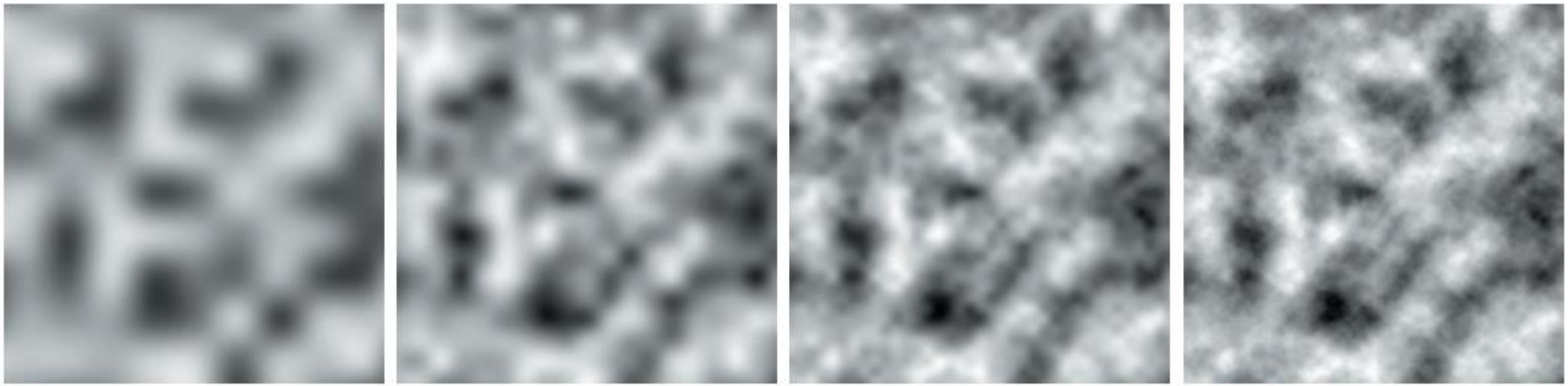
Example



2D cross sections of the fractal_sum function with 1 (a), 2 (b), 3 (c), and 8 (d) octaves

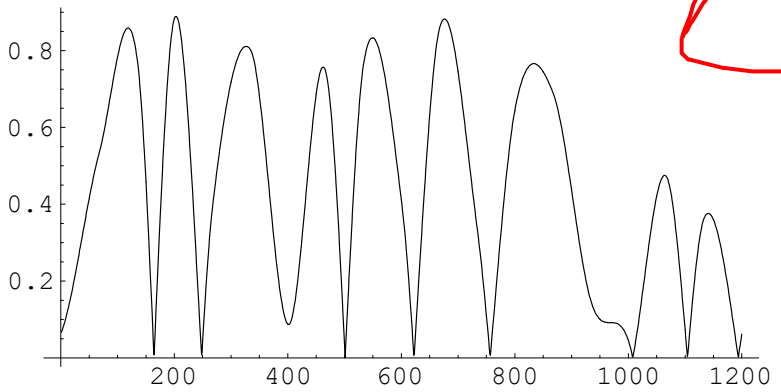
Turbulence

Turbulence (Perlin 85) is similar to fractal sum

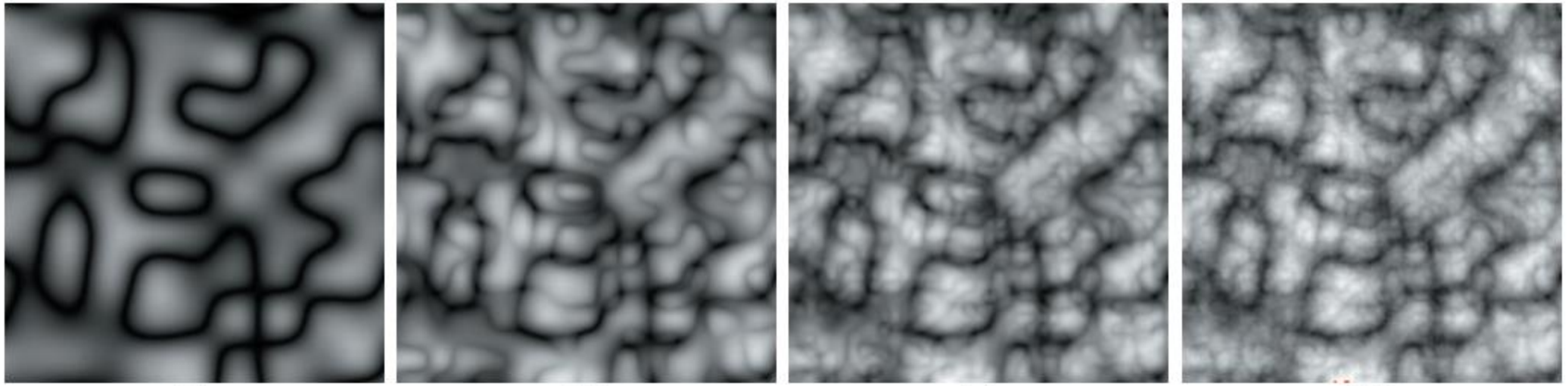
But it uses the absolute value of the noise function

$$turbulence(p) = \sum_{j=0}^{n-1} \frac{|noise(2^j p)|}{2^j}$$

$$turbulence(p) \approx \begin{cases} 0, & 2 \left(1 - \left(\frac{1}{2}\right)^{n-1}\right) \end{cases}$$



Turbulence



2D cross sections of the turbulence function with 1 (a), 2 (b), 3 (c), and 8 (d) octaves

Fractional Brownian Motion (fBm)

fBm generalizes fractal sum

- amplitudes change according a to ratio (gain)
- spatial frequencies change according to a ratio (lacunarity)

$$fBm(p) = \sum_{j=0}^{n-1} gain^j \cdot noise(lacunarity^j\, p)$$

$$fBm(p) \le \left[\frac{1 - gain^{n-1}}{1 - gain}\right]\left[\frac{1 - gain^{n-1}}{1 - gain}\right]$$

- What do we get with gain=0.5 and lacunarity=2?

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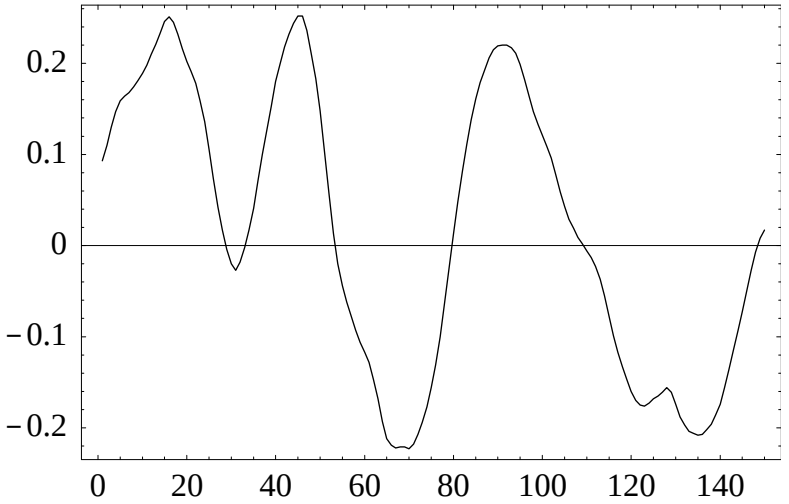
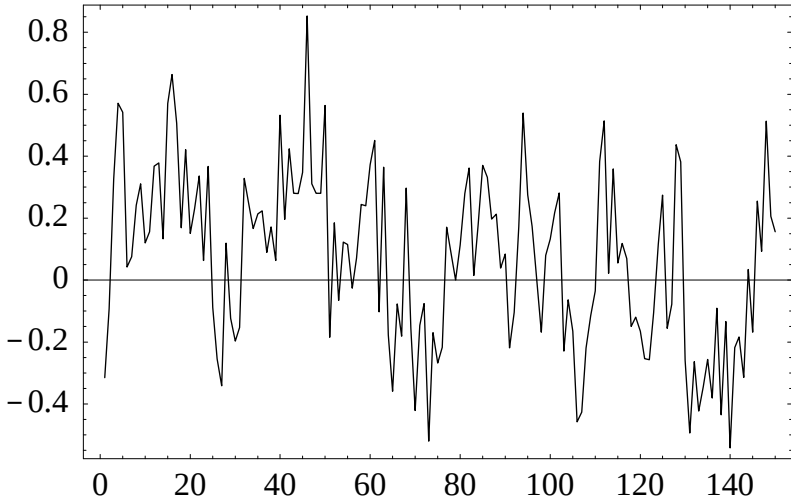
fBM Varying Gain



0.25



1.0

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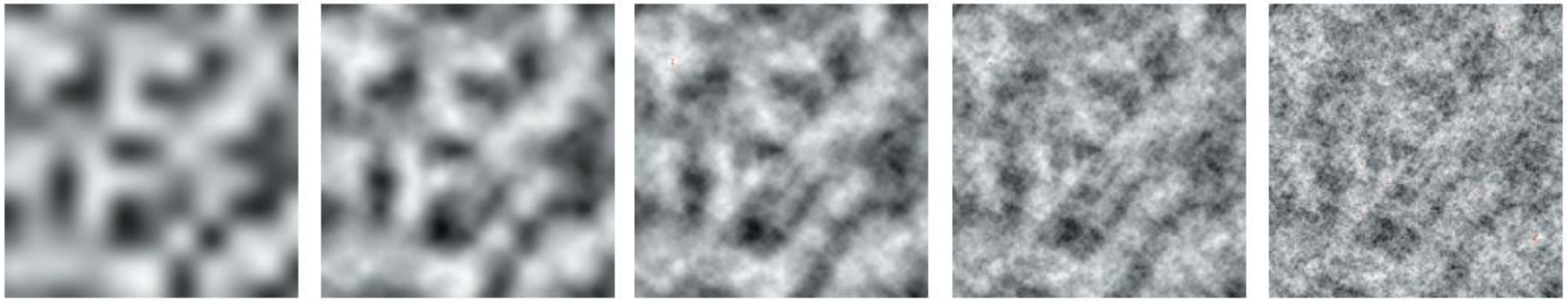
fBM Varying Gain

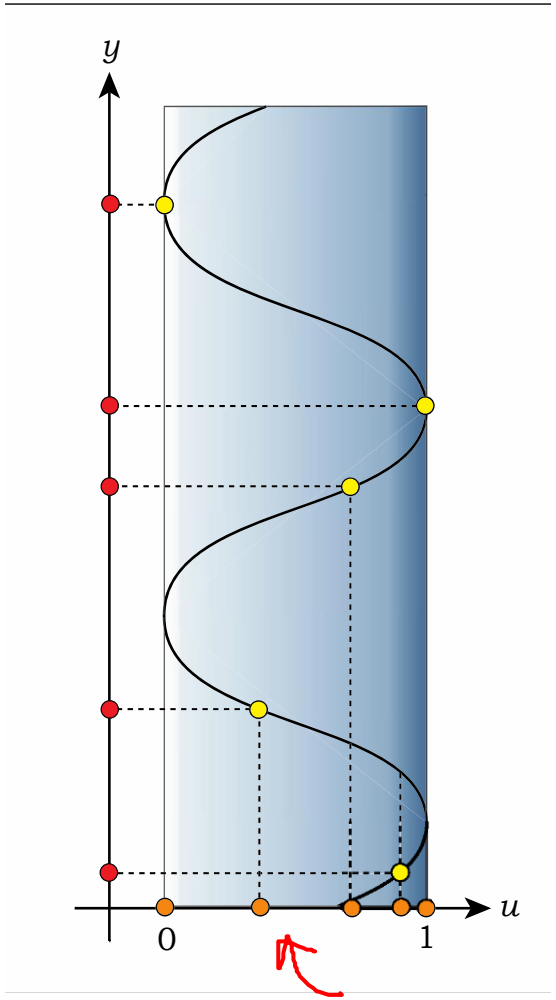


Varying the gain in the fBm function with six octaves and lacunarity = 2. From (a) to (e), gain = 0.0; 0.25; 0.5; 0.75; 1.0.

fBm Varying Lacunarity

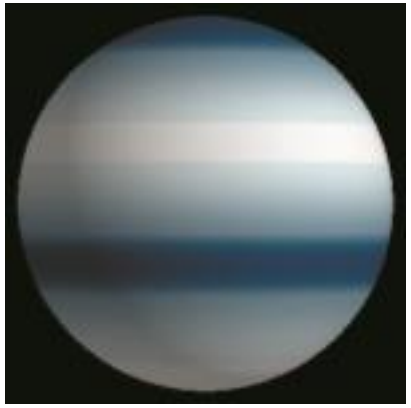
Varying the lacunarity in the fBm function with six octaves and gain = 0.5. From (a) to (e), lacunarity = 0.5; 1; 2; 4; 8.

Marble?



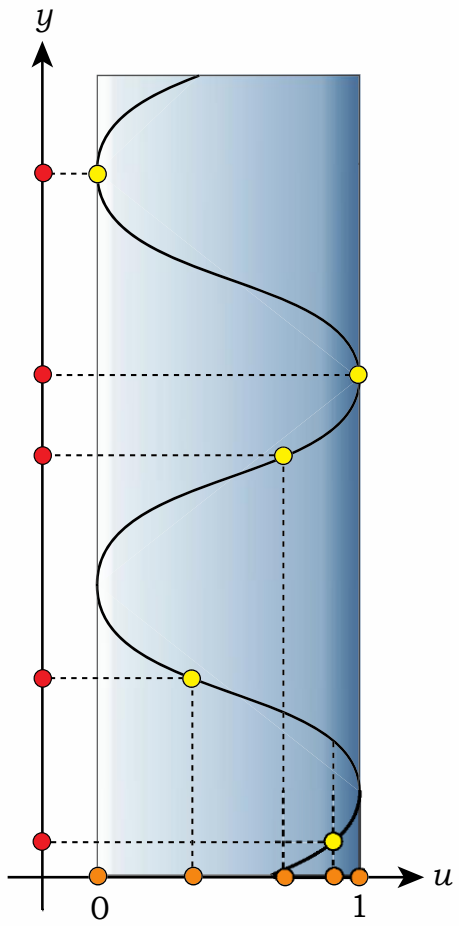
We will use a ramp to select a marble color

$$u = [1 + \sin(y)]/2.$$



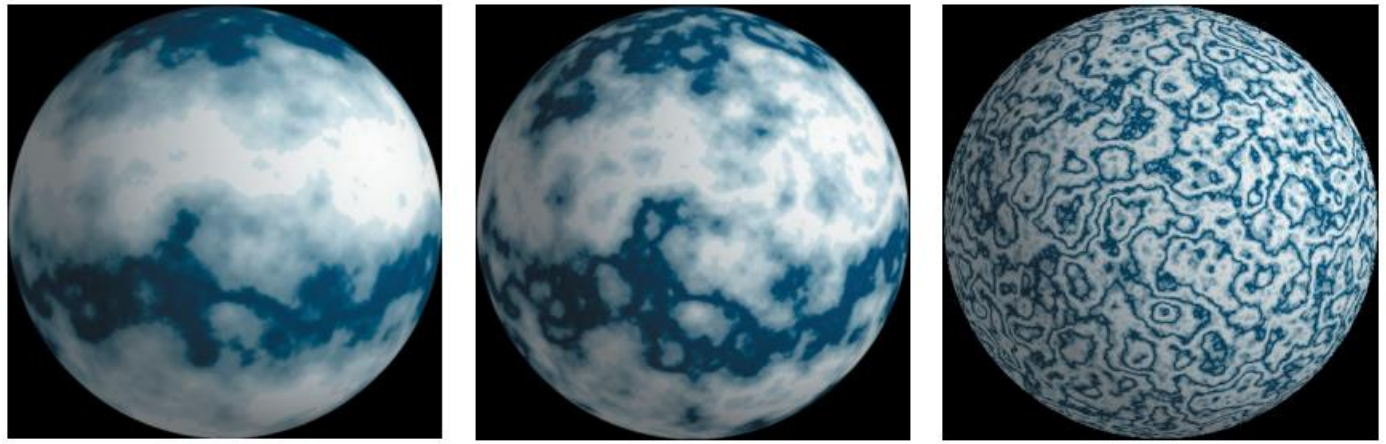
Marble

…we need to add some noise first



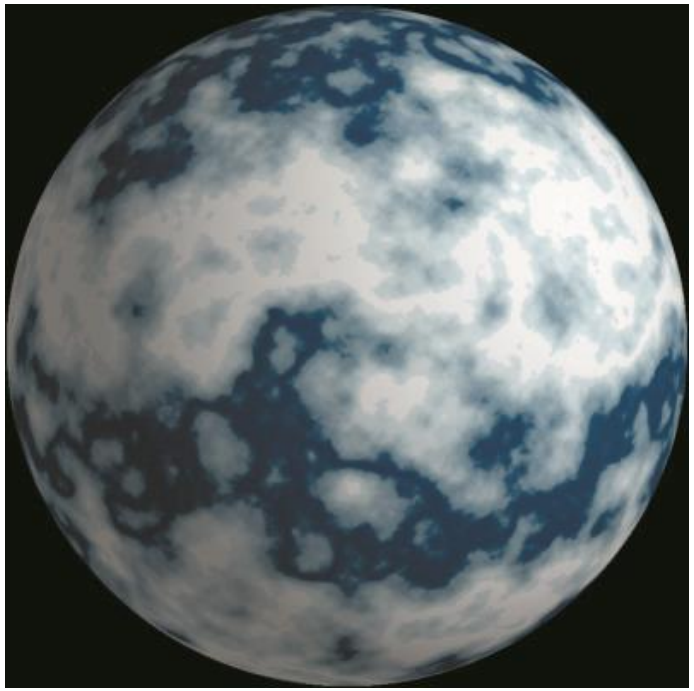
$$p.y = p.y + a(fractal\_sum(p))$$

$$u = \frac{[1+\sin(y)]}{2}$$



(a) (b) (c)

Marble Examples



Sandstone