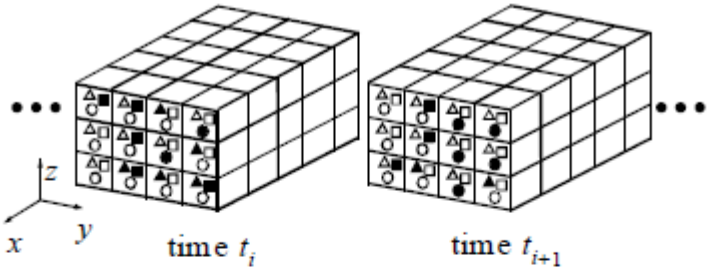
Clouds

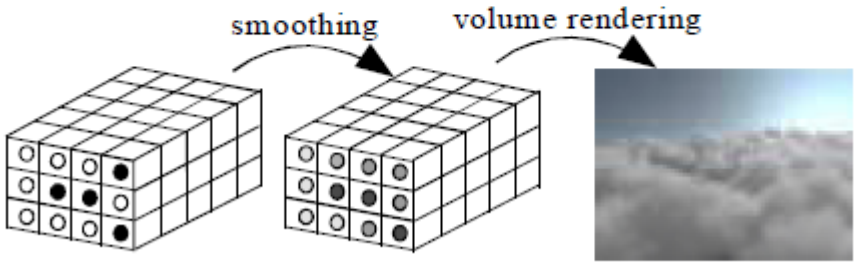
Cansın Yıldız

Theory

Overview – Dobashi et al.



(a) Simulation process.



(b) Rendering process.

Simulation

- Use a cellular automaton.
  - Each cell has vapor/humidity (*hum*), clouds (*cld*), and phase transition (*act*).
- Simulate by applying some transition rules based on *hum, cld, act.*
- A binary simulation result; cld: 1 or 0.

Simulation – Transitions

- Growth

$$hum(i,j,k,t_{i+1}) = hum(i,j,k,t_i) \wedge \neg act(i,j,k,t_i)\,, \qquad (1)$$

$$cld(i,j,k,t_{i+1}) = cld(i,j,k,t_i) \vee act(i,j,k,t_i)\,, \qquad (2)$$

$$act(i,j,k,t_{i+1}) = \neg act(i,j,k,t_i) \wedge hum(i,j,k,t_i) \wedge f_{act}(i,j,k)\,, \qquad (3)$$

$$\begin{aligned} f_{act}(i,j,k) = {} & act(i+1,j,k,t_i) \vee act(i,j+1,k,t_i) \\ & \vee act(i,j,k+1,t_i) \vee act(i-1,j,k,t_i) \vee act(i,j-1,k,t_i) \\ & \vee act(i,j,k-1,t_i) \vee act(i-2,j,k,t_i) \vee act(i+2,j,k,t_i) \\ & \vee act(i,j-2,k,t_i) \vee act(i,j+2,k,t_i) \vee act(i,j,k-2,t_i). \end{aligned} \qquad (4)$$

Simulation – Transitions

- Extinction

$$hum(i,j,k,t_{i+1}) = hum(i,j,k,t_i) \vee is(rnd < p_{hum}(i,j,k,t_i)), \quad (5)$$

$$cld(i,j,k,t_{i+1}) = cld(i,j,k,t_i) \wedge is(rnd > p_{ext}(i,j,k,t_i)), \quad (6)$$

$$act(i,j,k,t_{i+1}) = act(i,j,k,t_i) \vee is(rnd < p_{act}(i,j,k,t_i)), \quad (7)$$

- Use ellipsoids to set p_{hum}, p_{ext}, and p_{act}.
  - Far from an ellipsoid center → More chance of *ext*
  - Near to an ellipsoid center → More chance of *act, hum*

Rendering – Smoothing

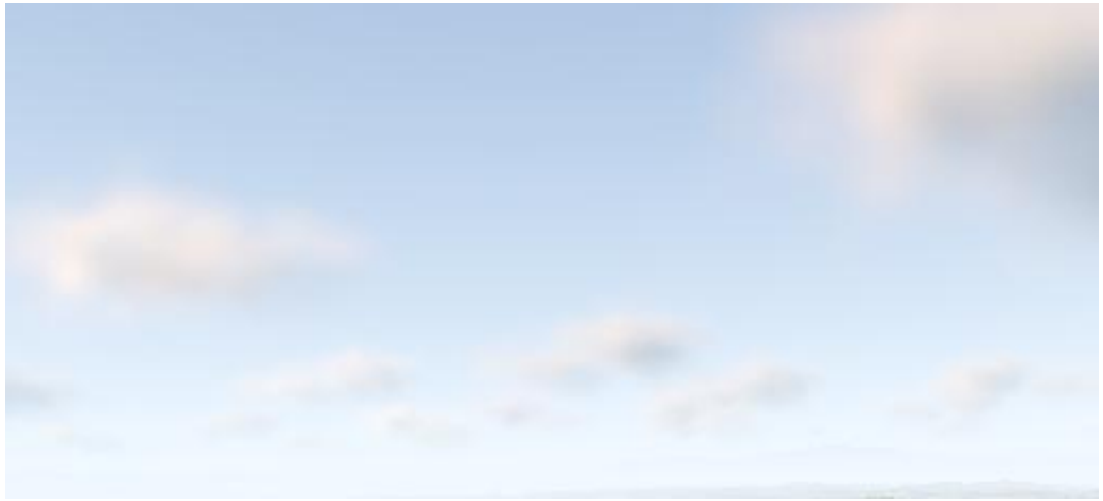
- Smooth binary simulation.
  - Apply Gaussian Filter on 4D; x, y, z, time.

$$q(i,j,k,t_{i+1}) = \frac{1}{(2i_0+1)(2j_0+1)(2k_0+1)(2t_0+1)} \sum_{t'=-t_0}^{t_0} \sum_{k'=-k_0}^{k_0} \sum_{j'=-j_0}^{j_0} \sum_{i'=-i_0}^{i_0} w(i',j',k',t') cld(i+i', j+j', k+k', t_i+t'), \quad (11)$$

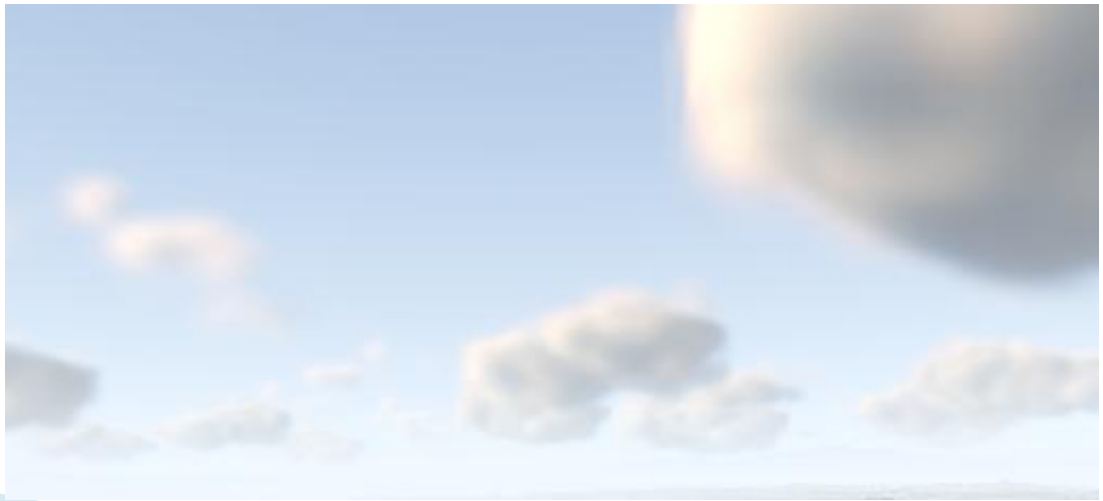
- Interpolate between time steps as well.

Gaussian Kernel Amplitude 0.03 vs. 1

0.03



1

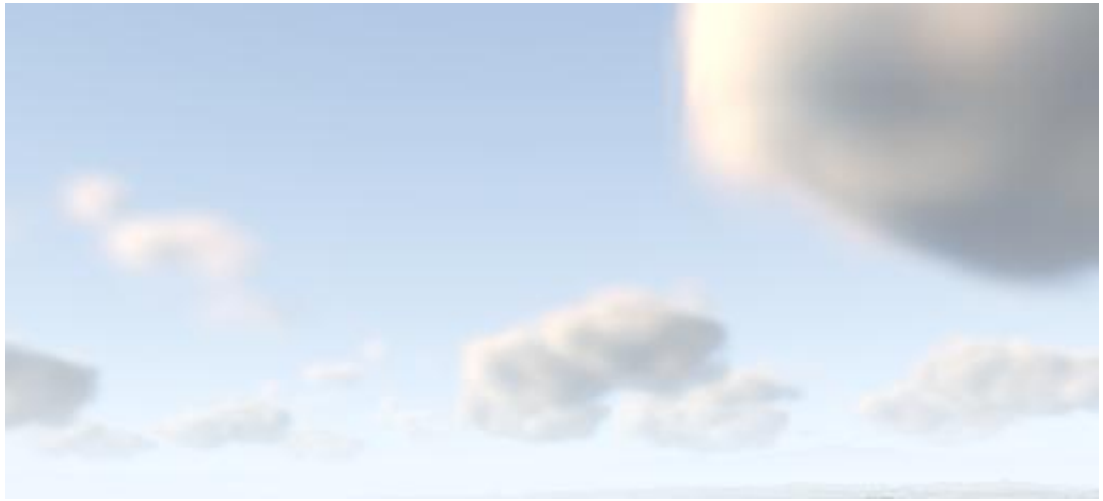


Rendering – PovRay

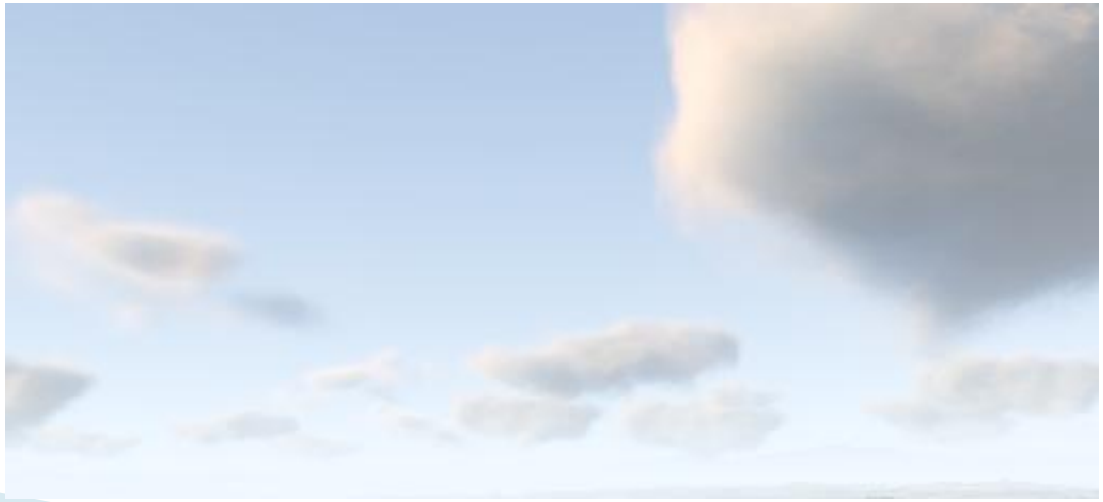
- Use PovRay to do final rendering.

No Turbulence vs. Turbulence

No Turbulence



Turbulence



Results

Time for Videos

Thank You.