Atmospheric Processes

Atmospheric processes
- Mixing
- Radiation
- Condensation/Evaporation
- Precipitation

Surface exchanges
- Friction
- Sensible heat flux
- Latent heat flux

Surface variables
- Surface roughness
- Surface temperature
- Snow
- Soil moisture
- Melting
Atmospheric Processes

- Atmospheric processes
- Mixing Radiation Condensation/Evaporation
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- Surface exchanges
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- Surface variables
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- Surface temperature

- Atmospheric prognostic variables
- Wind
- Temperature
- Humidity
- Cloud Water/Ice

- Sensible heat flux
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- Melting
- Snow
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Atmospheric Processes

- Atmospheric processes
  - Mixing
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- Atmospheric prognostic variables
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- Surface exchanges
  - Friction
  - Sensible heat flux
  - Latent heat flux

- Surface variables
  - Surface roughness
  - Surface temperature
  - Snow
  - Soil moisture
  - Melting
Supercomputer power and data are limiting factors.
Modeling dilemma ...

<table>
<thead>
<tr>
<th>Resolution</th>
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<th>SAR</th>
<th>TAR</th>
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<td>-180 km (163)</td>
<td>-110 km (106)</td>
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Complexity

Figure 1.2: The complexity of climate models has increased over the last few decades. The additional processes incorporated in the models are shown pictorially by the different colors of the modeled areas.
Relevant temporal and spatial scales

<table>
<thead>
<tr>
<th>Time scale (seconds)</th>
<th>10^0</th>
<th>10^2</th>
<th>10^4</th>
<th>10^6</th>
<th>10^8</th>
<th>10^10</th>
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<tbody>
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<table>
<thead>
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<tr>
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</tr>
<tr>
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</tr>
</tbody>
</table>
Relevant temporal and spatial scales

- **Horizontal length scale (km)**: 1, 10, 100, 1000, 10000
- **Time scale (seconds)**: 10^0, 10^2, 10^4, 10^6, 10^8, 10^10

Scale categories:
- **minute**
- **day**
- **year**
- **century**

Turbulence region highlighted.
Relevant temporal and spatial scales

Time scale (seconds)

- minute
- day
- year
- century

Horizontal length scale (km)

- 1
- 10
- 100
- 1000
- 10000

Turbulence

Thermals
Relevant temporal and spatial scales

Time scale (seconds)
- minute
- day
- year
- century

Horizontal length scale (km)
- turbulence
- thermals
- cumulus

Relevant temporal and spatial scales
Relevant temporal and spatial scales

<table>
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<th>Horizontal length scale (km)</th>
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</tbody>
</table>

- KNMI
- Koninklijk Nederlands Meteorologisch Instituut
Relevant temporal and spatial scales

turbulence
thermals
thunderstorms
sea breeze

time scale (seconds)
10^0 10^2 10^4 10^6 10^8 10^10

minute  day  year  century

horizontal length scale (km)
1
10
100
1000
10000
Relevant temporal and spatial scales

- Turbulence
- Thermals
- Thunderstorms
- Sea breeze
- Synoptic-scale system

Time scale (seconds):
- 10^0
- 10^2
- 10^4
- 10^6
- 10^8
- 10^10

Horizontal length scale (km):
- 1
- 10
- 100
- 1000
- 10000
- 100000
- 1000000

- Minute
- Day
- Year
- Century
Relevant temporal and spatial scales

<table>
<thead>
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<th>Time scale (seconds)</th>
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<td>10</td>
<td>10 ^ 8</td>
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<tr>
<td>1</td>
<td>10 ^ 10</td>
</tr>
</tbody>
</table>

- turbulence
- thermals
- cumulus
- sea breeze
- thunderstorms
- synoptic-scale system
- monsoon
Relevant temporal and spatial scales

- Turbulence
- Thermals
- Thunderstorms
- Sea breeze
- Synoptic-scale system
- Monsoon
- Interseasonal vegetation
- Cumulus

Time scale (seconds):
- 10
- 10^2
- 10^4
- 10^6
- 10^8
- 10^10

Horizontal length scale (km):
- 1
- 10
- 100
- 1000
- 10000
- 100000

- Minute
- Day
- Year
- Century
Relevant temporal and spatial scales

- Turbulence
- Thermals
- Thunderstorms
- Sea breeze
- Synoptic-scale system
- Monsoon
- Soil moisture
- Interseasonal vegetation
- Cumulus
- Horizontal length scale (km)
- Time scale (seconds)
- Minute
day
- Year
- Century
- $10^0$, $10^2$, $10^4$, $10^6$, $10^8$, $10^{10}$
Relevant temporal and spatial scales

- Turbulence
- Thermals
- Thunderstorms
- Sea breeze
- Synoptic-scale system
- Monsoon
- El Niño
- Soil moisture
- Interseasonal vegetation
- Cumulus
- Horizontal length scale (km)

- Minute
- Day
- Year
- Century

- Time scale (seconds)
Relevant temporal and spatial scales

- Turbulence
- Thermals
- Thunderstorms
- Sea breeze
- Synoptic-scale system
- Monsoon
- El Niño
- Soil moisture
- Soil erosion
- Interseasonal vegetation
- Cumulus
- Horizontal length scale (km)
  - 1
  - 10
  - 100
  - 1000
  - 10000
- Time scale (seconds)
  - 10^0
  - 10^2
  - 10^4
  - 10^6
  - 10^8
  - 10^10

- Relevant temporal scales:
  - Minute
  - Day
  - Year
  - Century
Relevant temporal and spatial scales

- Turbulence
- Thermals
- Thunderstorms
- Sea breeze
- Synoptic-scale system
- Monsoon
- El Niño
- Ocean circulation
- Soil moisture
- Soil erosion
- Interseasonal vegetation
- Cumulus
- Horizontal length scale (km)
- Time scale (seconds)

- Minute
- Day
- Year
- Century
Relevant temporal and spatial scales

- Turbulence
- Thermals
- Thunderstorms
- Sea breeze
- Synoptic-scale system
- Monsoon
- El Niño
- Ocean circulation
- Soil moisture
- Soil erosion
- Interseasonal vegetation
- Cumulus
- Time scale (seconds): 10\(^0\) to 10\(^{10}\)
- Horizontal length scale (km): 1\(^0\) to 10000\(^0\)
Relevant temporal and spatial scales

<table>
<thead>
<tr>
<th>Horizontal length scale (km)</th>
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- Turbulence
- Thermals
- Cumulus
- Thunderstorms
- Sea breeze
- Soil moisture
- Interseasonal vegetation
- Soil erosion
- Synoptic-scale system
- Monsoon
- El Niño
- Ocean circulation
- Global climate
- CO2 variations
- Minute
- Day
- Year
- Century
Spatial and Temporal Scales (2)
Spatial and Temporal Scales (2)

Nowcasting (up to 12 hours)

Local/Regional (mesh: 0.5-10km)
Spatial and Temporal Scales (2)

- Nowcasting (up to 12 hours)
- Short-range (6-48 hours)
- Local/Regional (mesh: 0.5-10km)
- Continental (mesh: 5-50km)
Spatial and Temporal Scales (2)

Nowcasting (up to 12 hours)
Local/Regional (mesh: 0.5-10km)

Short-range (6-48 hours)
Continental (mesh: 5-50km)

Medium-range 1-10 days
Global (mesh: 40-200 km)
Spatial and Temporal Scales (2)

- **Nowcasting** (up to 12 hours)
- **Short-range** (6-48 hours)
- **Medium-range** 1-10 days
- **Long-range** (months, seasonal)

**Local/Regional** (mesh: 0.5-10km)

**Continental** (mesh: 5-50km)

**Global** (mesh: 40-200 km)

**Global** (mesh: 100-400 km)

Need SST-forecast