Simple Statistical Models of Thunderstorms

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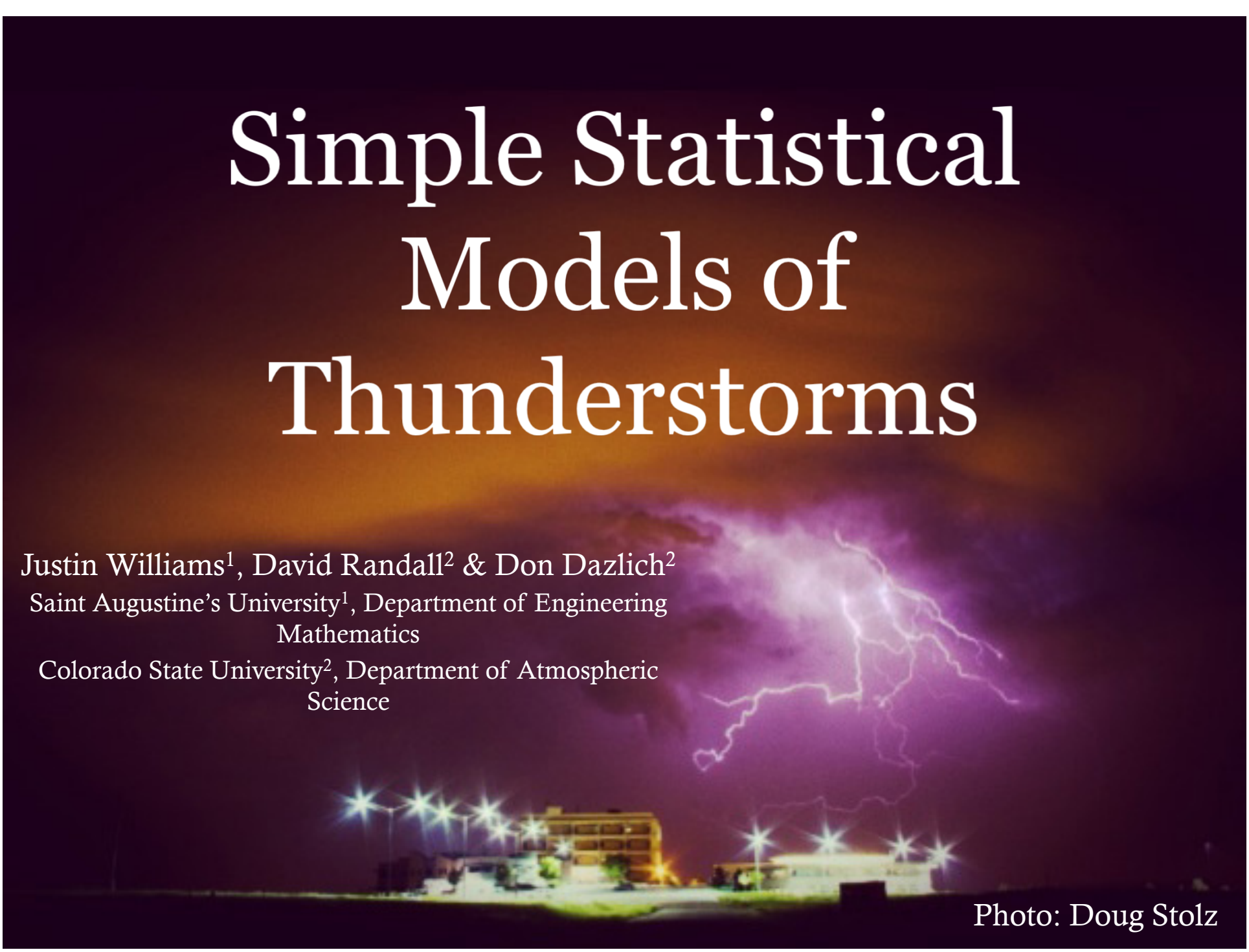
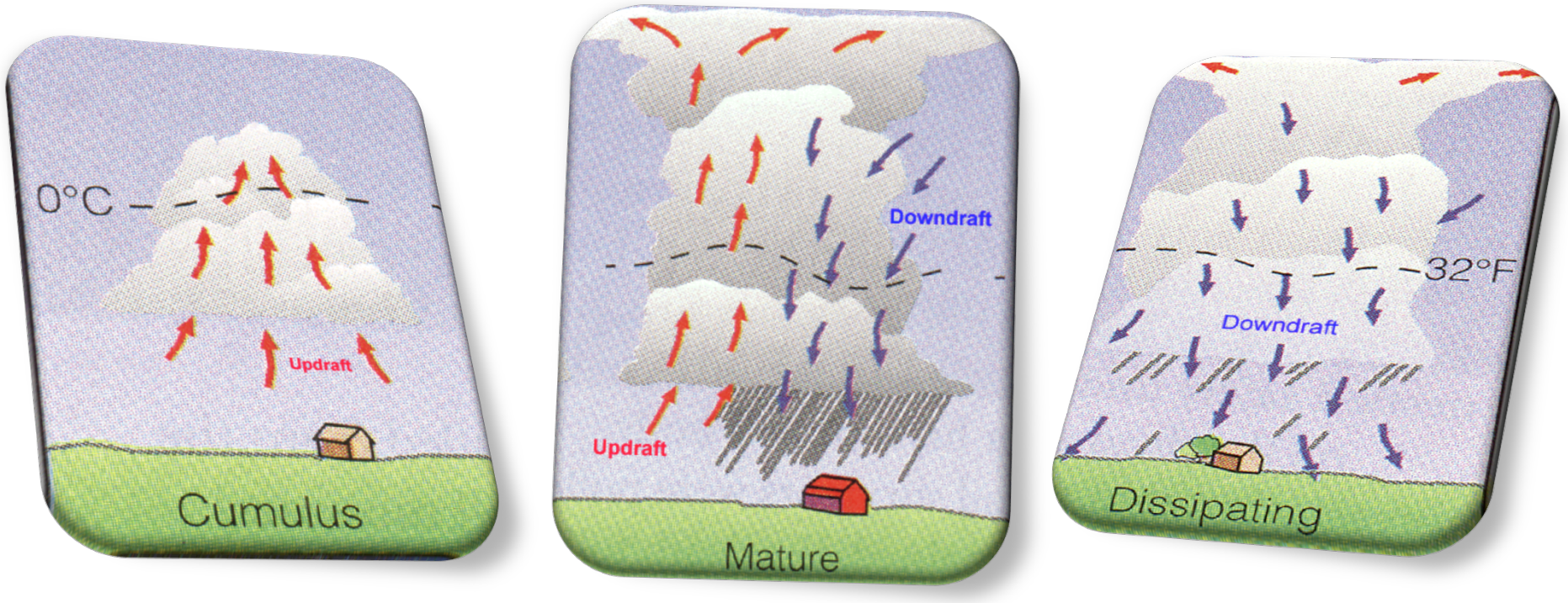


Photo: Doug Stolz

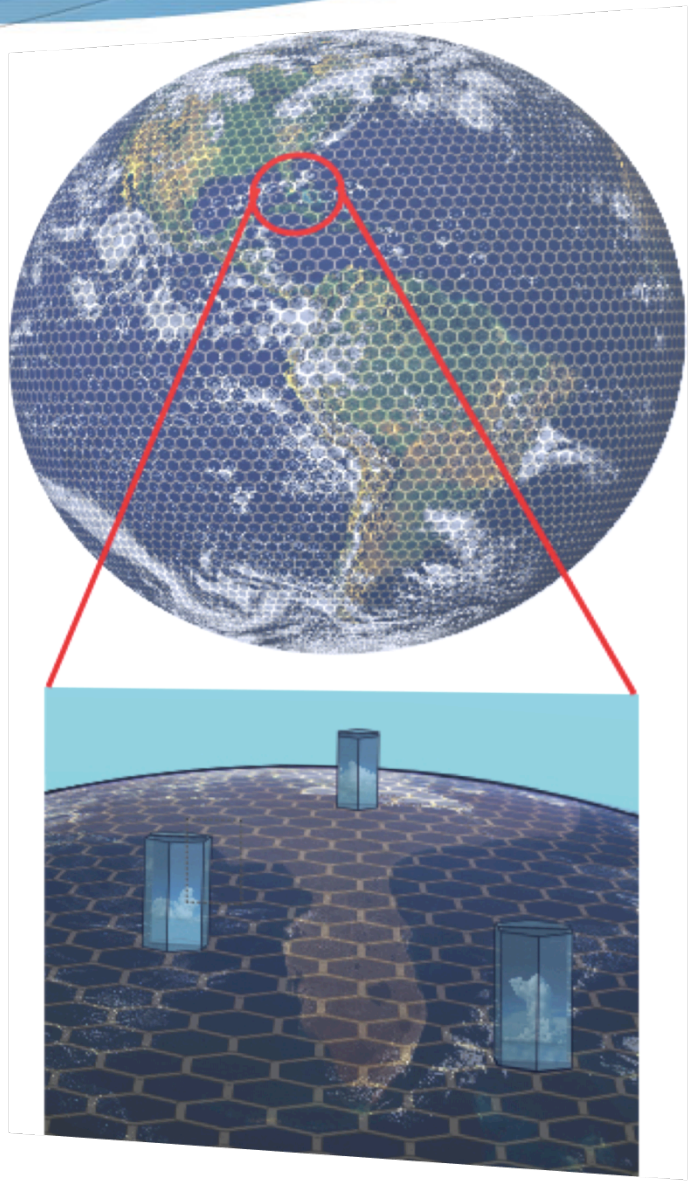
Thunderstorms

- Flux (movement) of temperature and moisture creating a cloud
  - Updrafts- carry warm moist air up
  - Downdrafts- carry cold air down
    - Slow downdraft = large area
    - Fast downdraft = small area

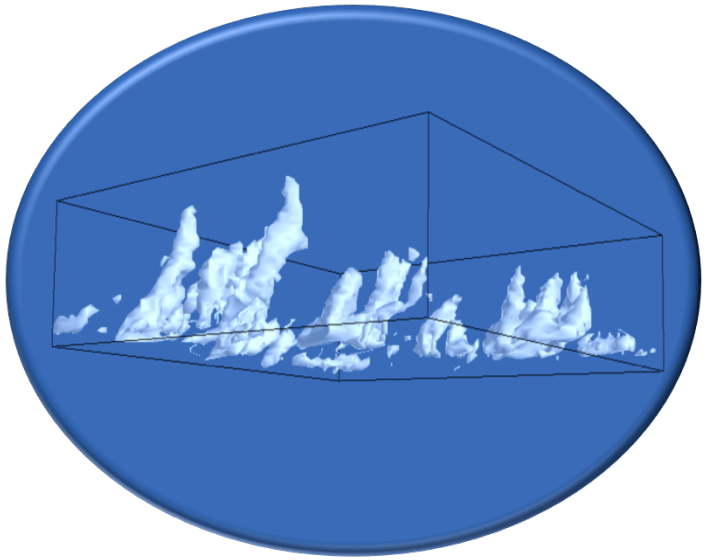


Cloud-resolving Models(CRMs)

- High-resolution simulations
- Domain size 1/20th of Colorado or the size of Rhode Island
- Started w/ 12 gigabytes of data
  - 2048x2048x256(Giga Model)
  - Number of grid points in whole domain
- 800 m data is 1/64 of full-resolution data



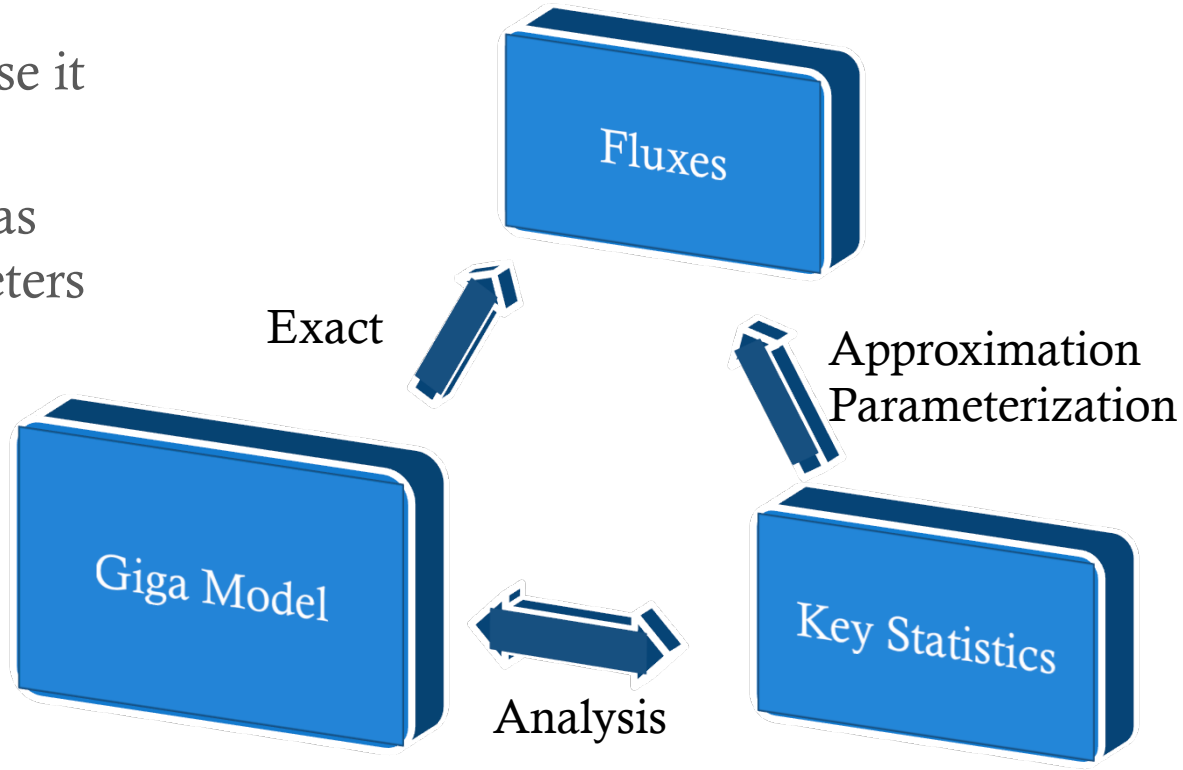
Flux Parameterization



- True fluxes computed from data on model grid
- Approximate parameterization
  - Updrafts and downdrafts represented by a pair of trivariate Gaussian distributions
  - Gaussian parameters diagnosed from numerical results
  - Approximate fluxes from Gaussians
  - Compare with true fluxes

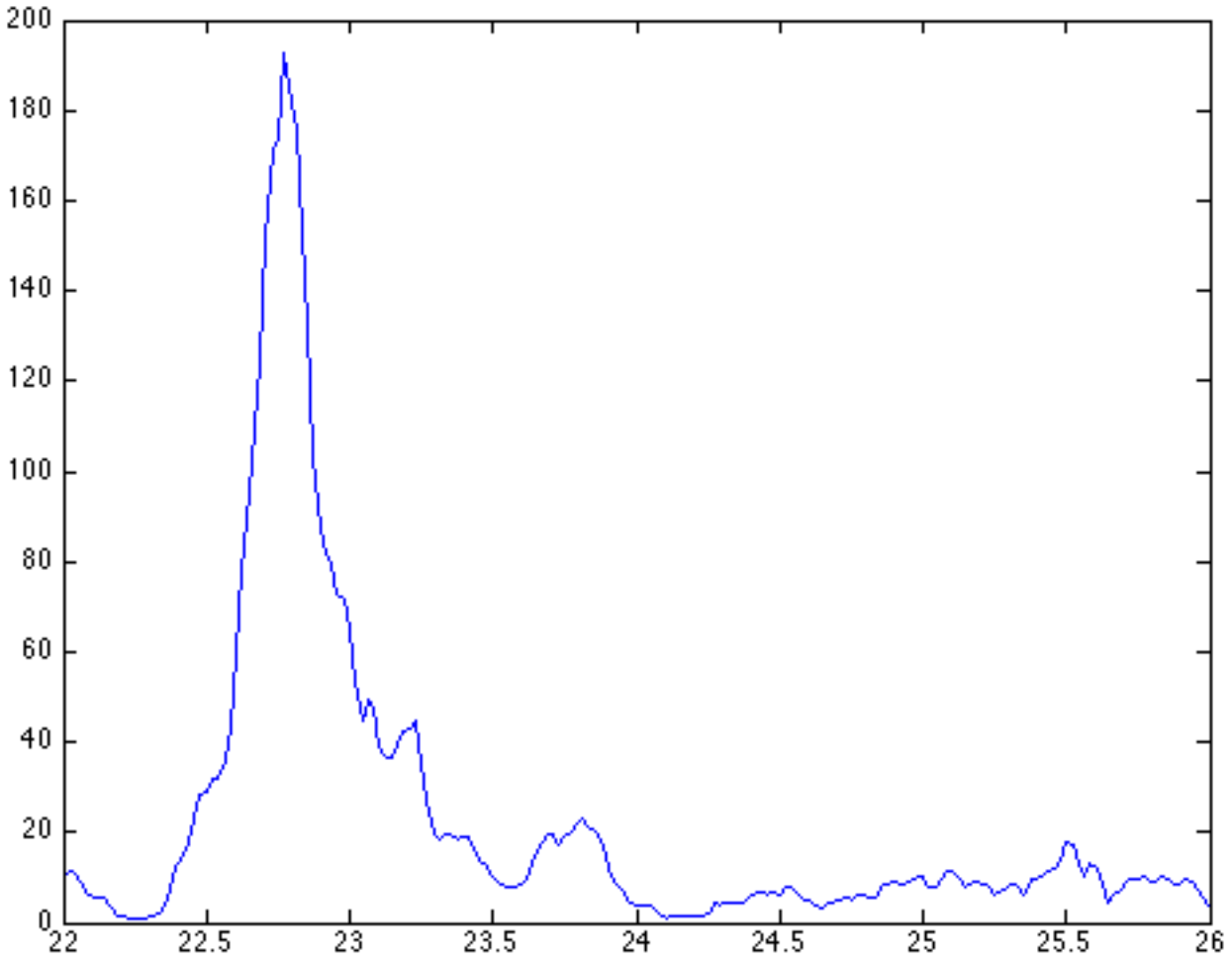
Cloud Model as Testbed

- If parameterization works well, we can use it in a global model.
- Global model then has to predict the parameters of the Gaussians.

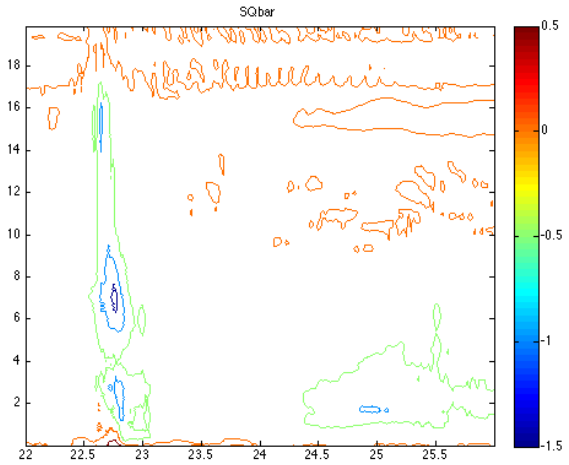


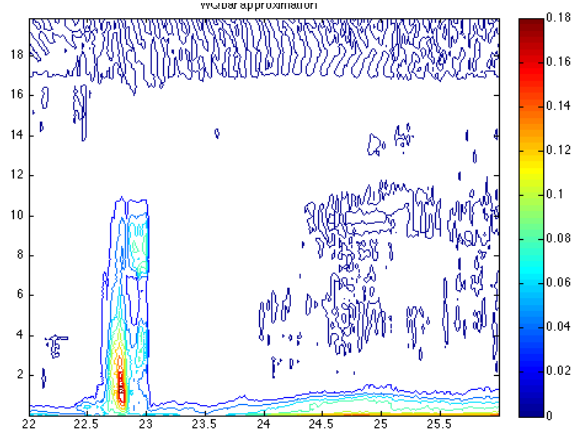
Surface Precipitation

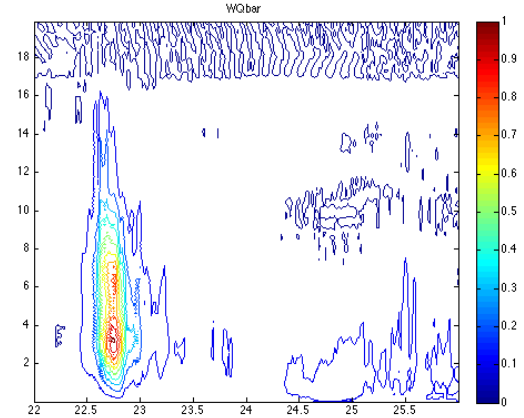
mm/ day

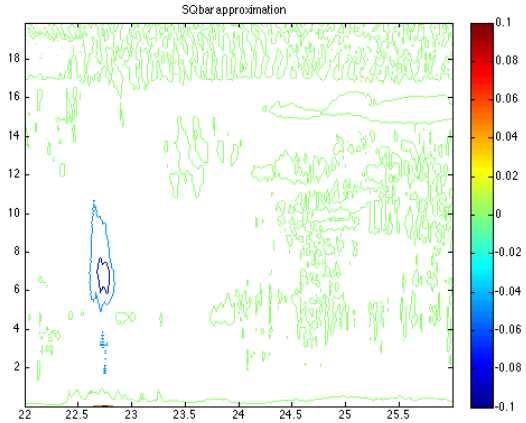


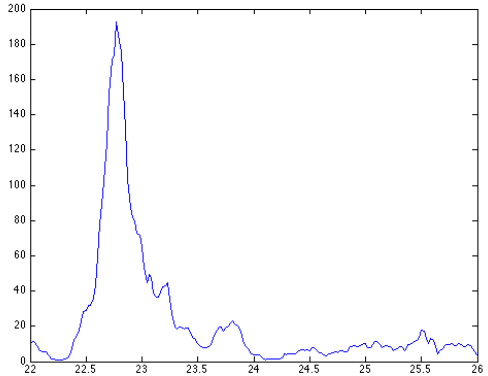
Days

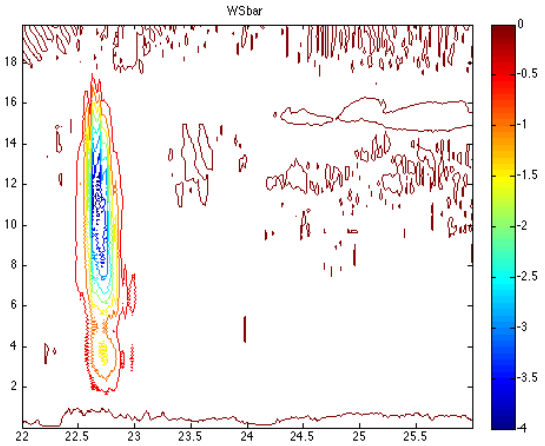

SQbar

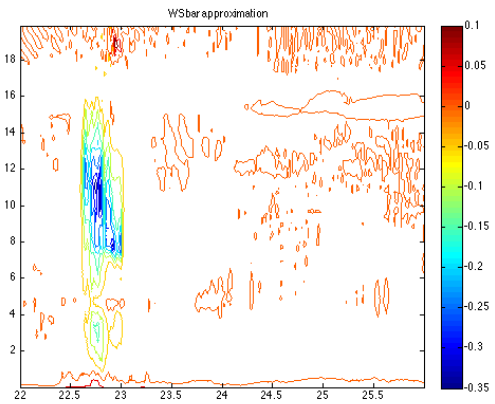

WQbar approximation

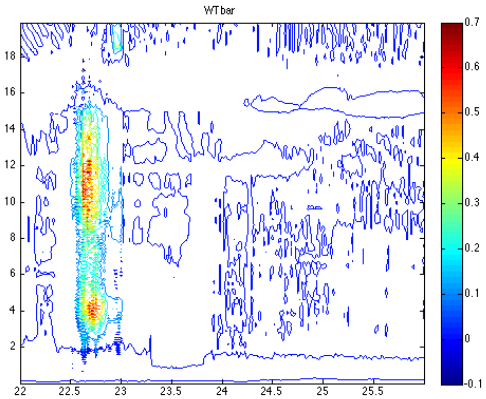

WQbar

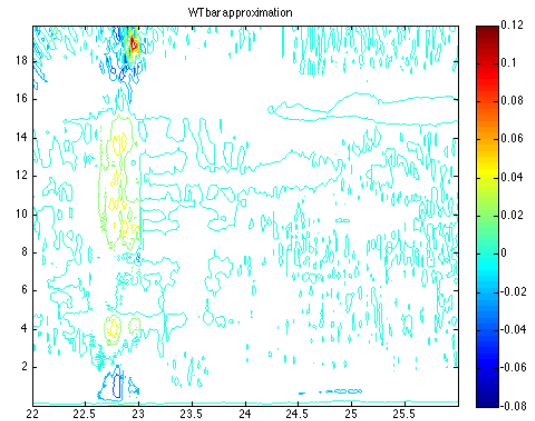

SQbar approximation




WSbar

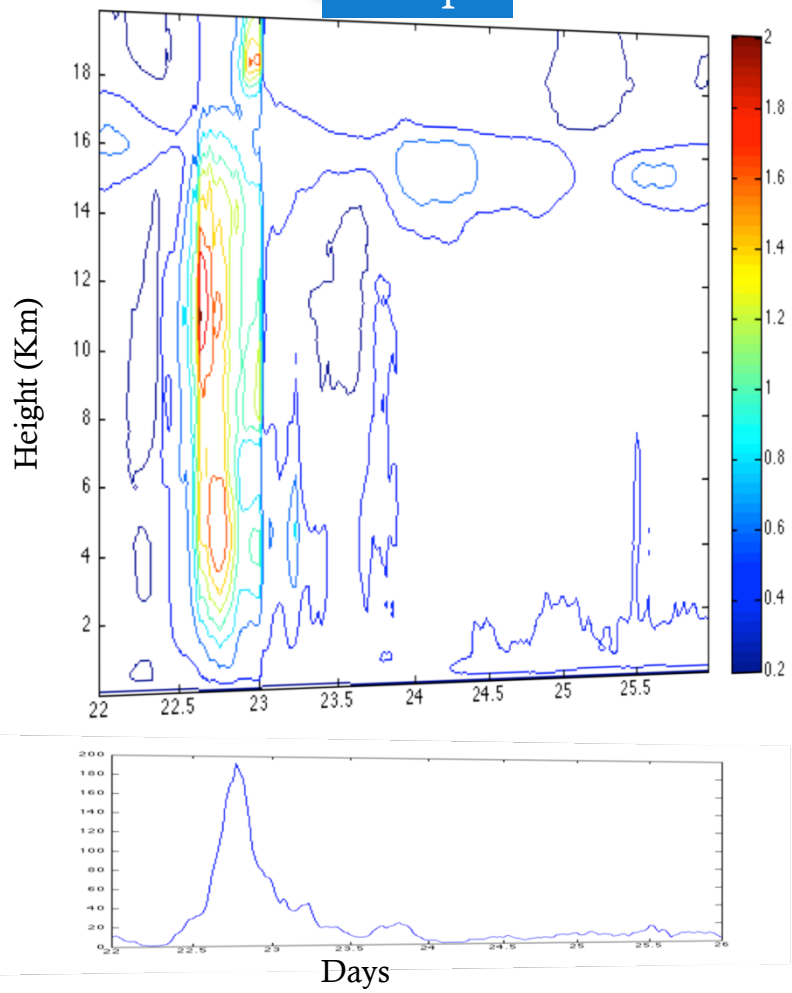

WSbar approximation


WTbar


WTbar approximation

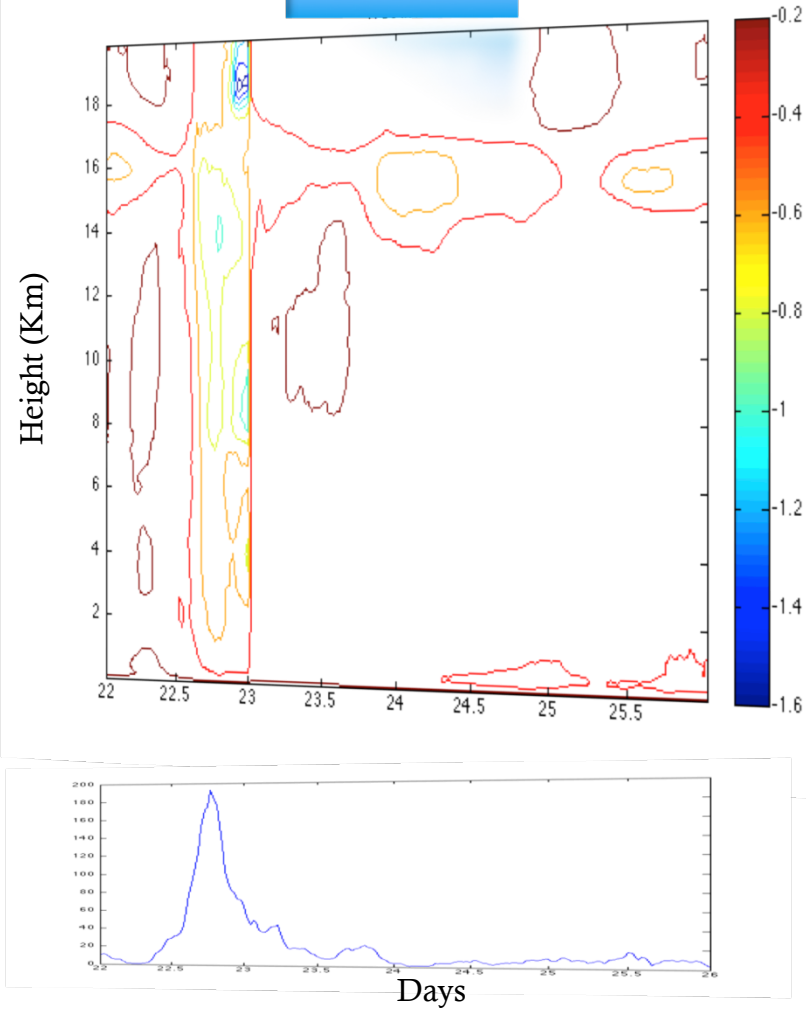
W-up and W-down

W Up



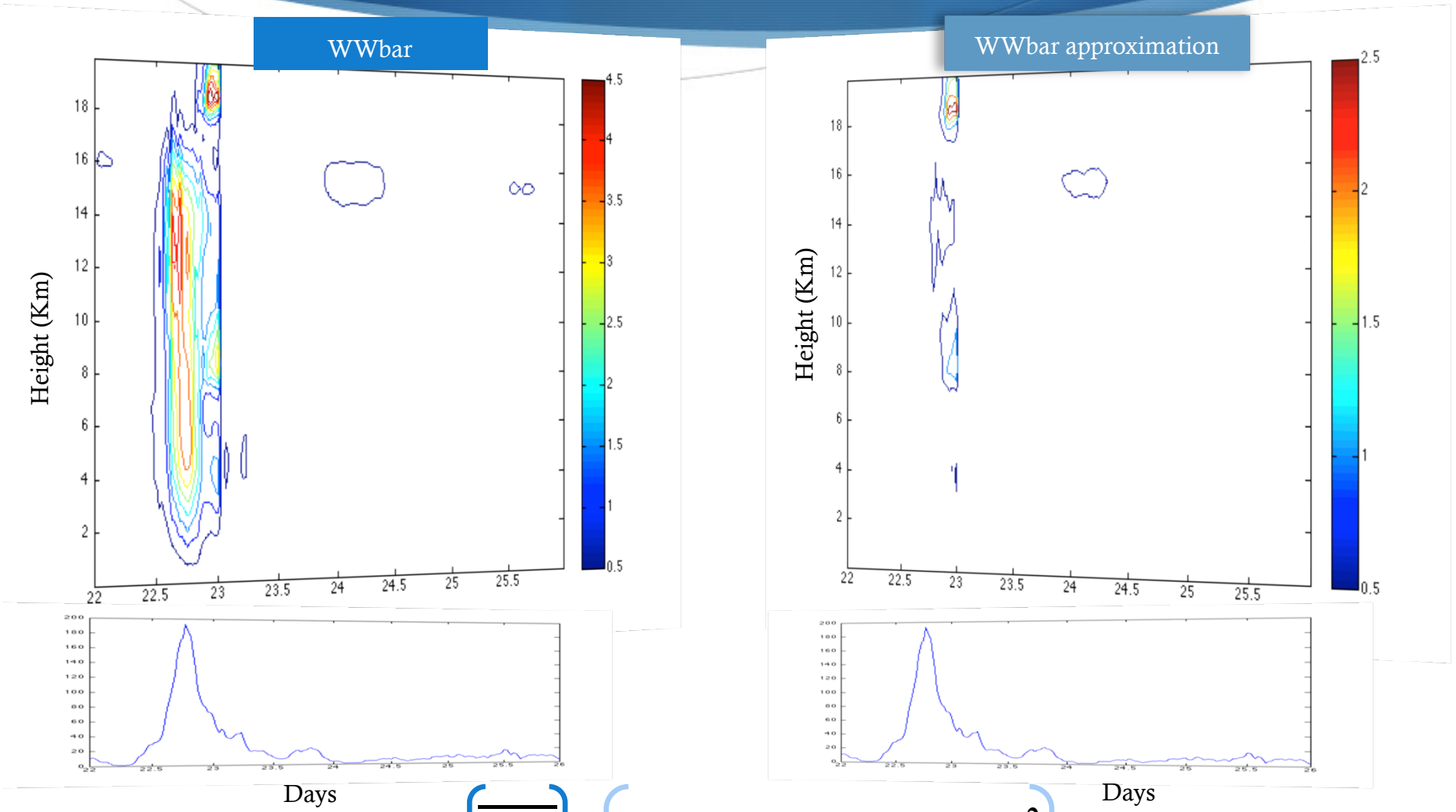
$$W_u = W\left(W > 0.1\right)$$

W Down



$$W_d = W\left(W < -0.1\right)$$

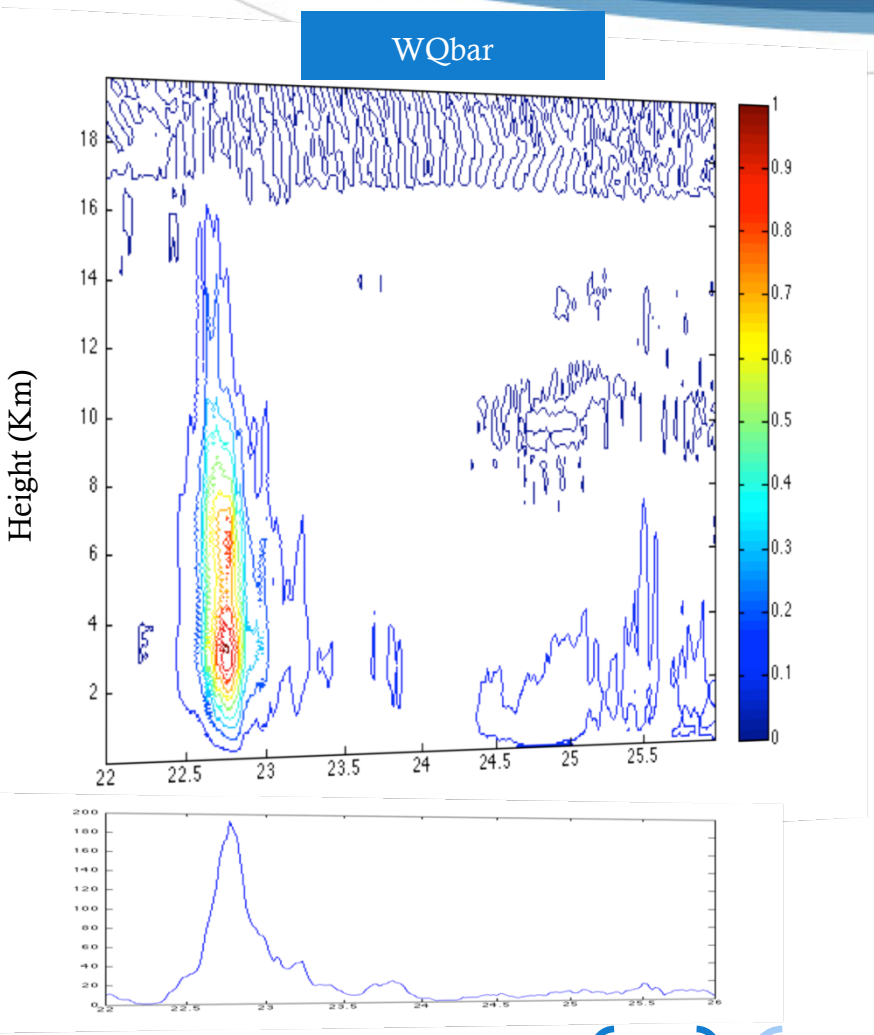
2nd Moment of W



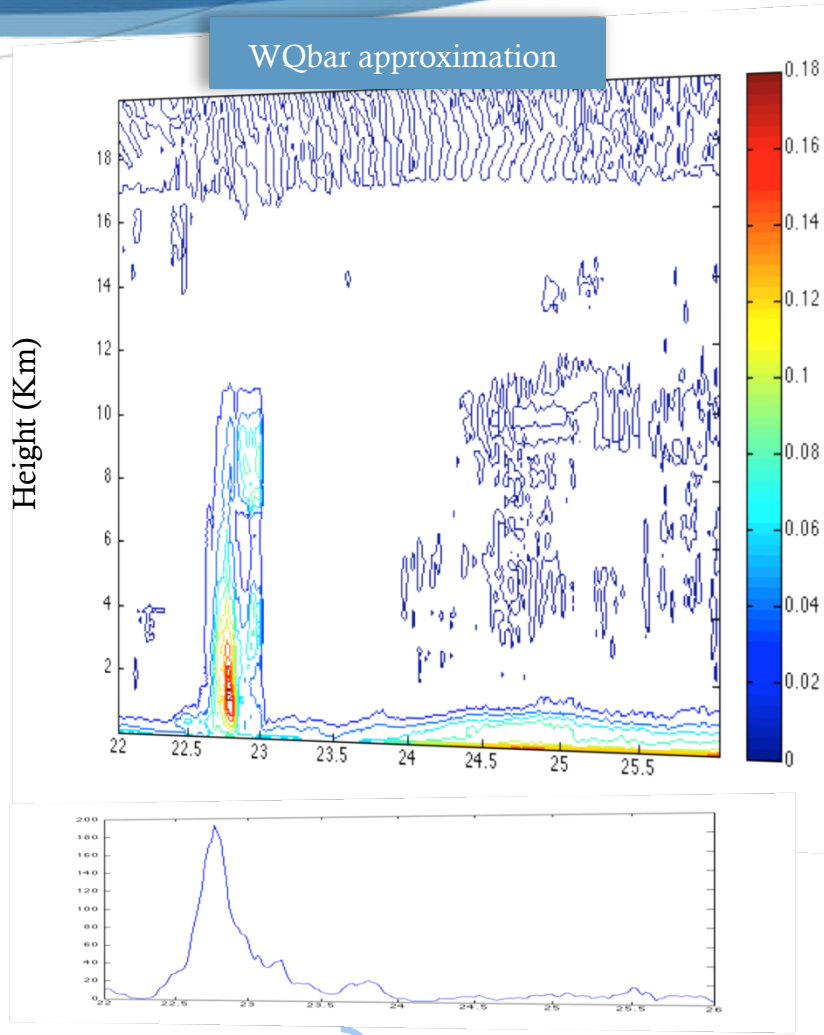
$$\overline{W'^2} \cong a_w\left(1-a_w\right)\left(W_u - W_d\right)^2$$

Moisture Flux

WQbar



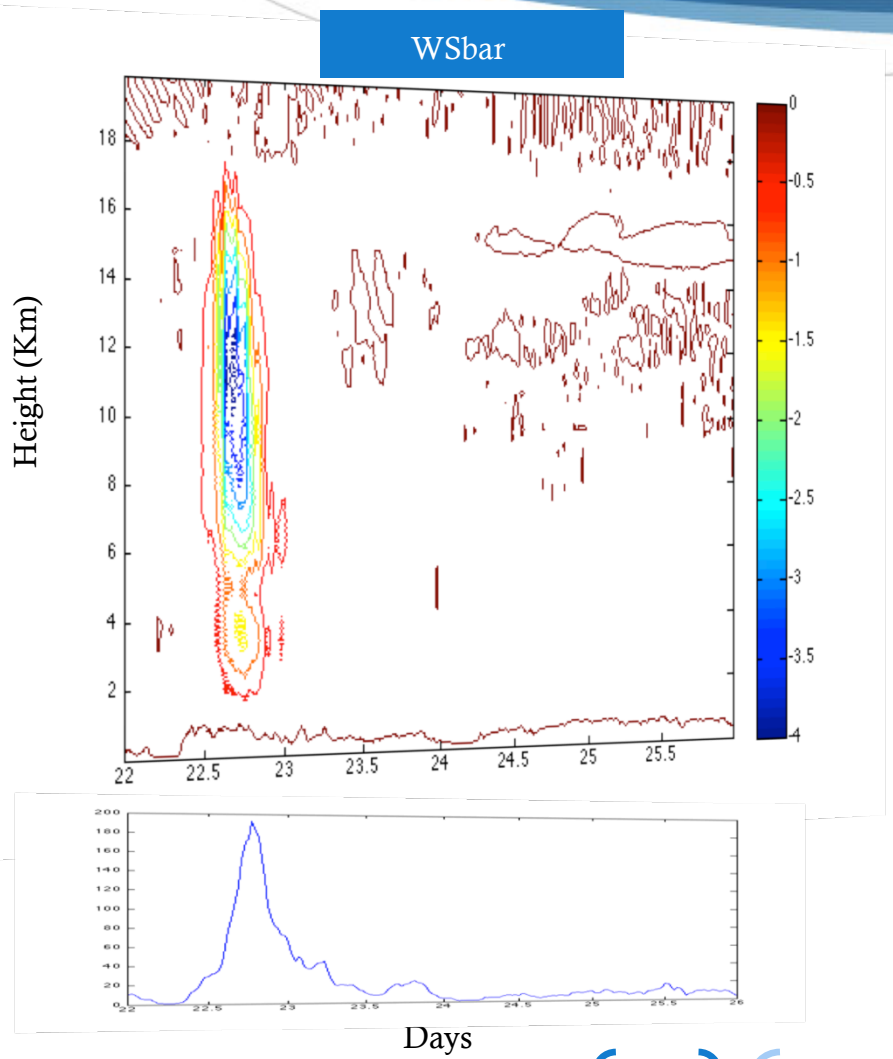
WQbar approximation



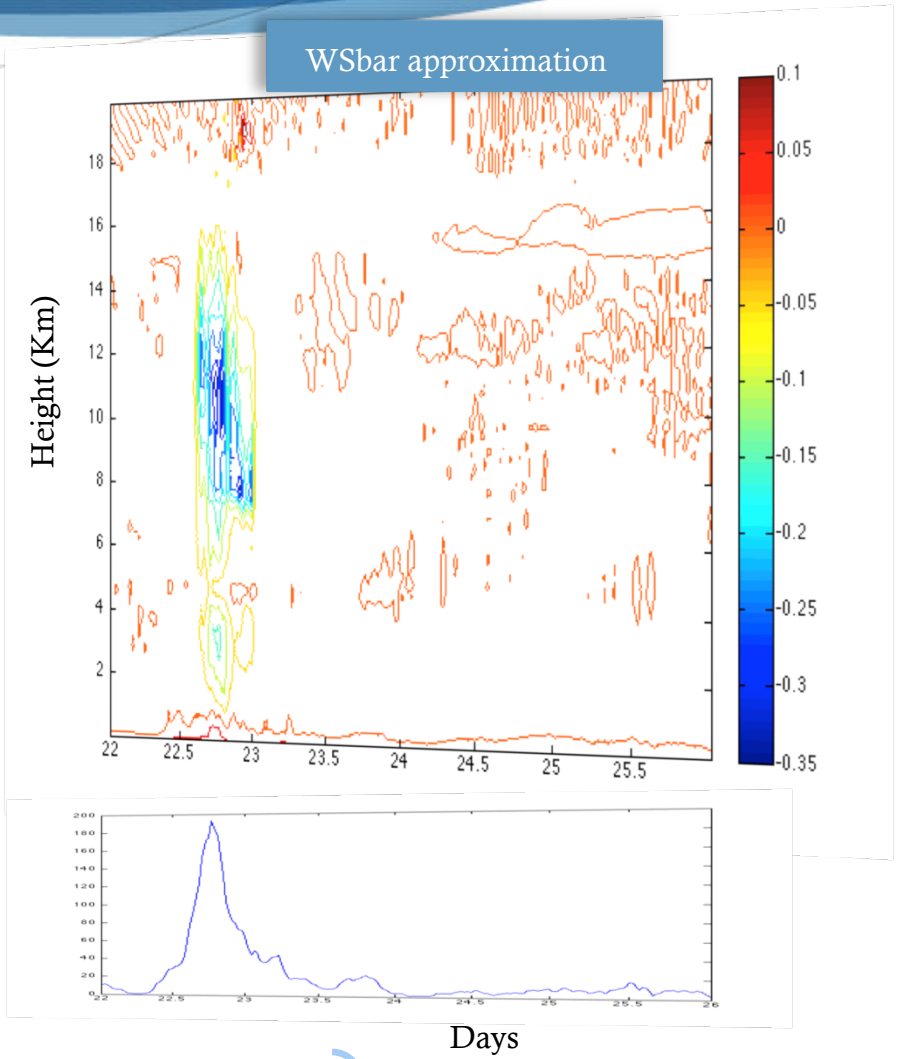
$$\left[\overline{W'Q'}\right] \cong \left[a_w\left(1-a_w\right)\left(W_u-W_d\right)\left(Q_u-Q_d\right)\right]$$

Energy Flux

WSbar



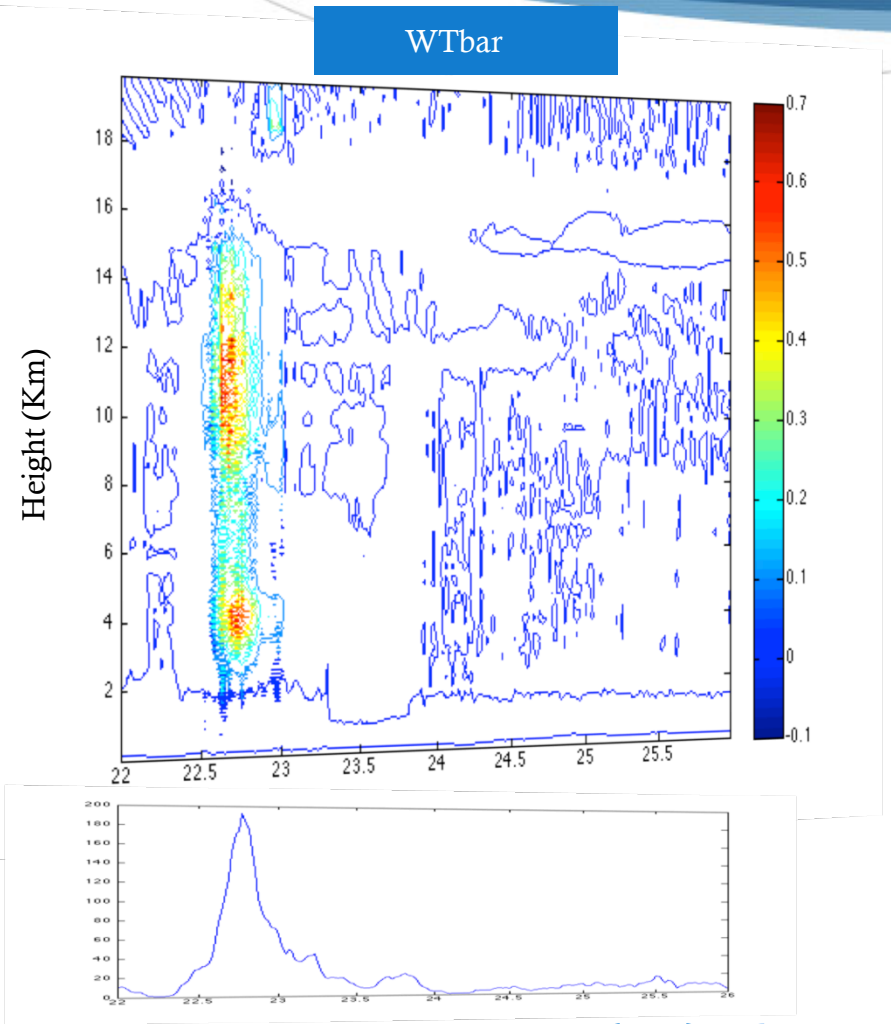
WSbar approximation



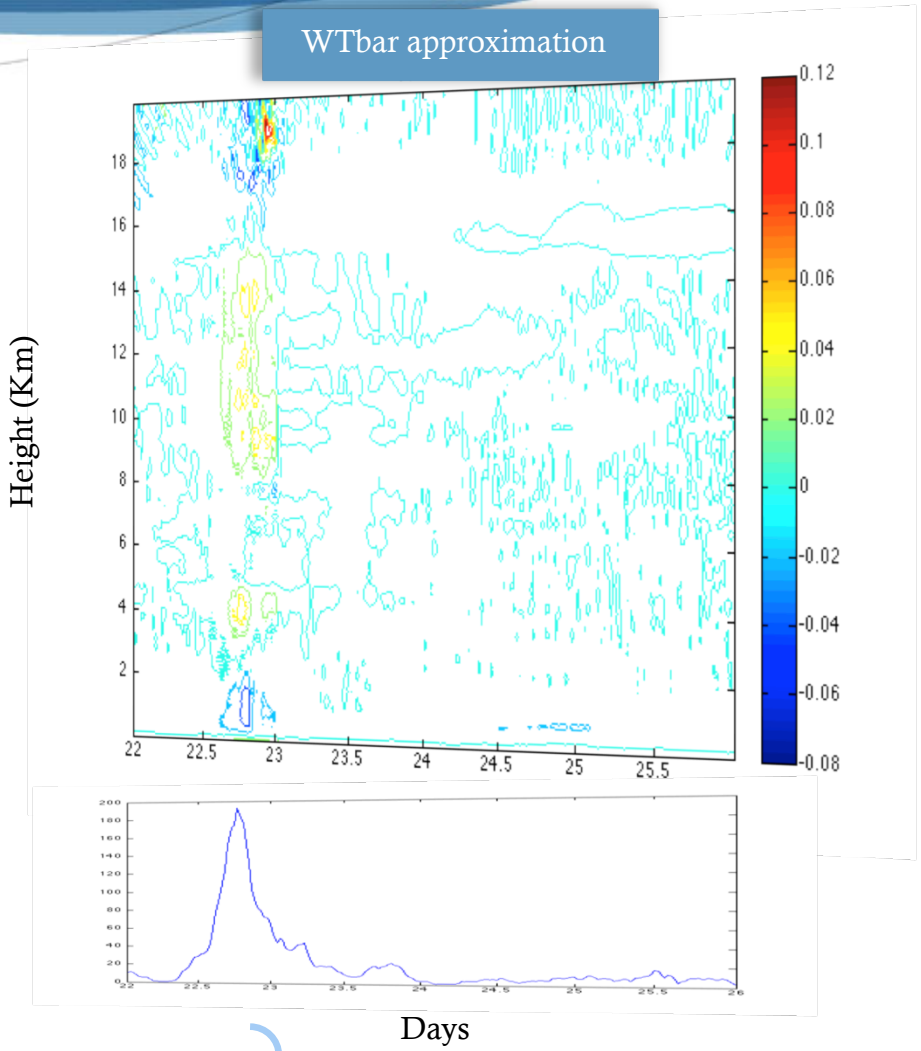
$$\left[\overline{W'S'}\right] \cong \left[a_w\left(1-a_w\right)\left(W_u-W_d\right)\left(S_u-S_d\right)\right]$$

Temperature Flux

WTbar



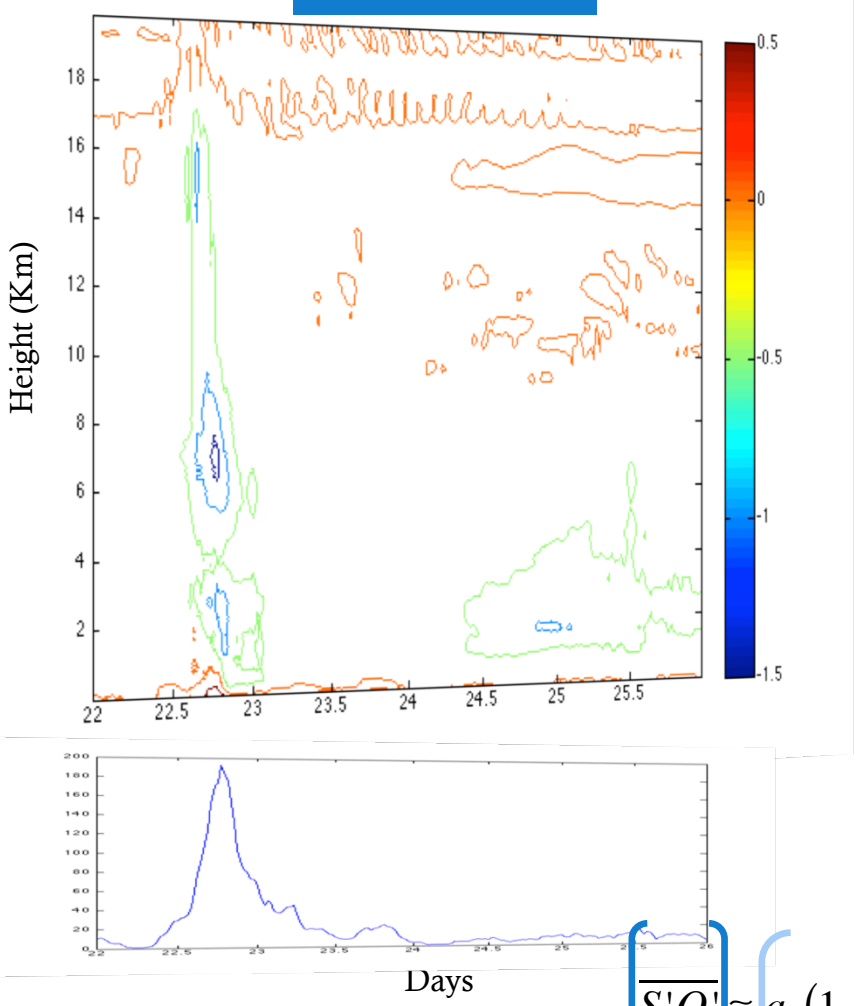
WTbar approximation



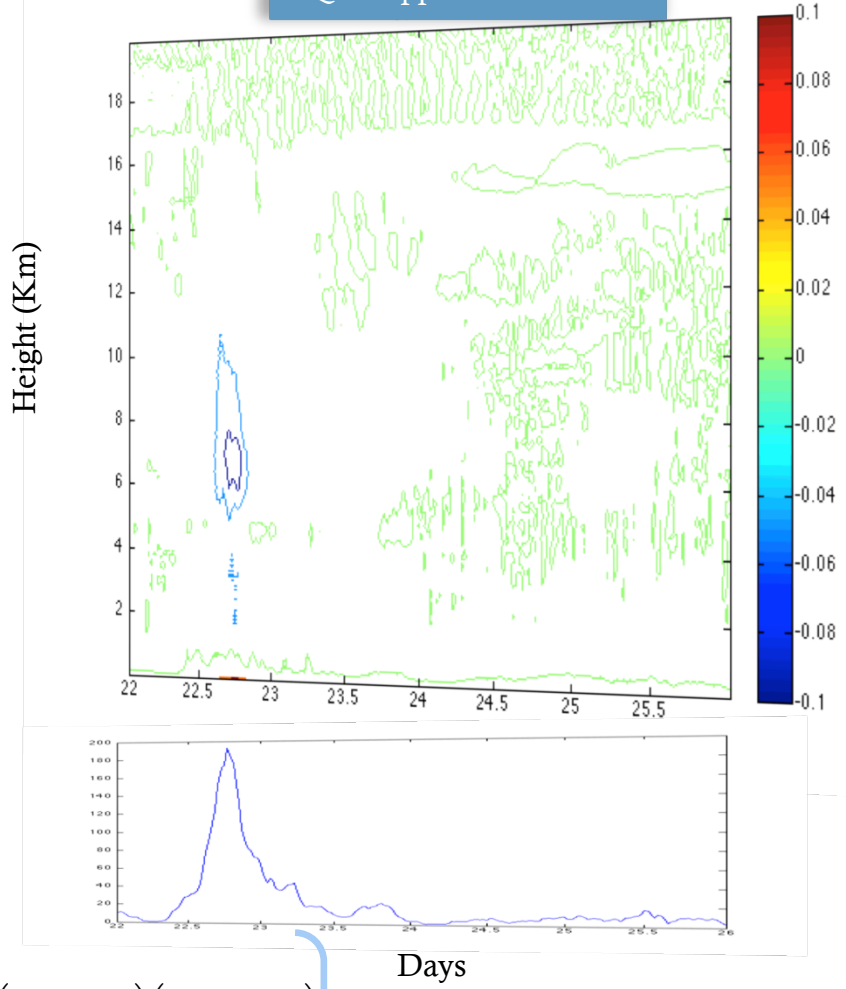
$$\left[\overline{W'T'}\right] \cong \left[a_w\left(1-a_w\right)\left(W_u-W_d\right)\left(T_u-T_d\right)\right]$$

Covariance

SQbar



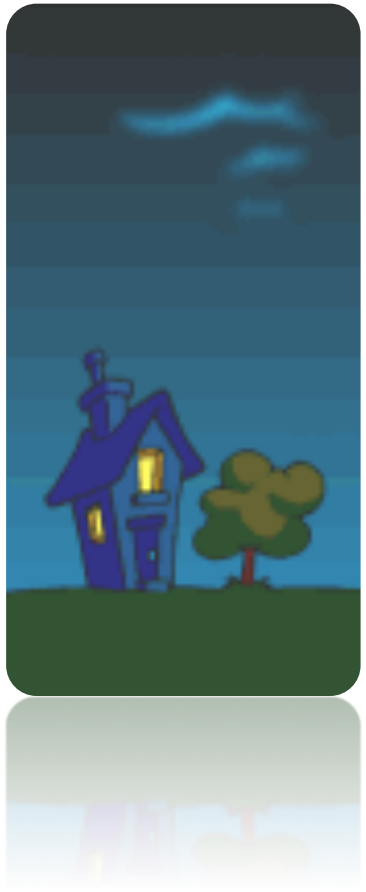
SQbar approximation



$$\left[\overline{S'Q'}\right] \cong \left[a_s\left(1-a_s\right)\left(S_u-S_d\right)\left(Q_u-Q_d\right)\right]$$

Conclusions

- Regional Giga model runs on a super computer.
  - High resolution for a small area
- Model is used to test a parameterization.
  - Approximations can be tested.
  - Changes can be made if necessary.
  - After testing, parameterization can be used in a global model.



References

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Questions