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TEAM-X Report: Chemistry and Dispersion Group A

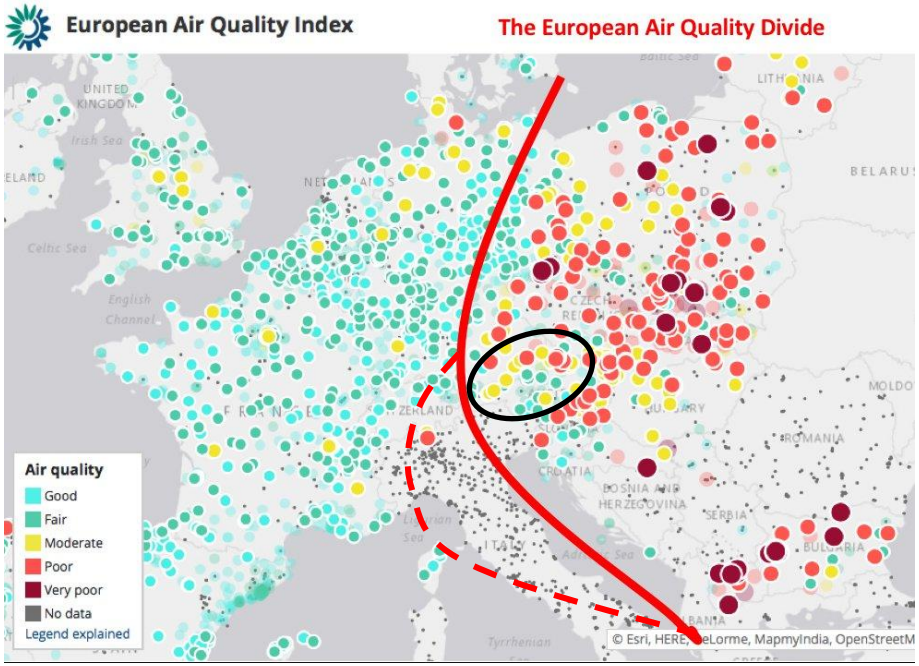
The Alps as a chemistry test-bed for mountainous areas world wide

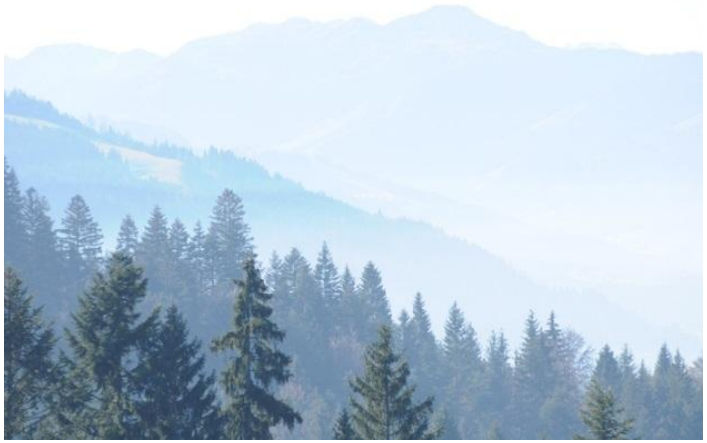
Air pollution and Climate change in Complex Topography

Smog envelops Santiago in Chile

OP-ed https://www.nature.com/articles/d41586-018-06150-5

View towards Innsbruck

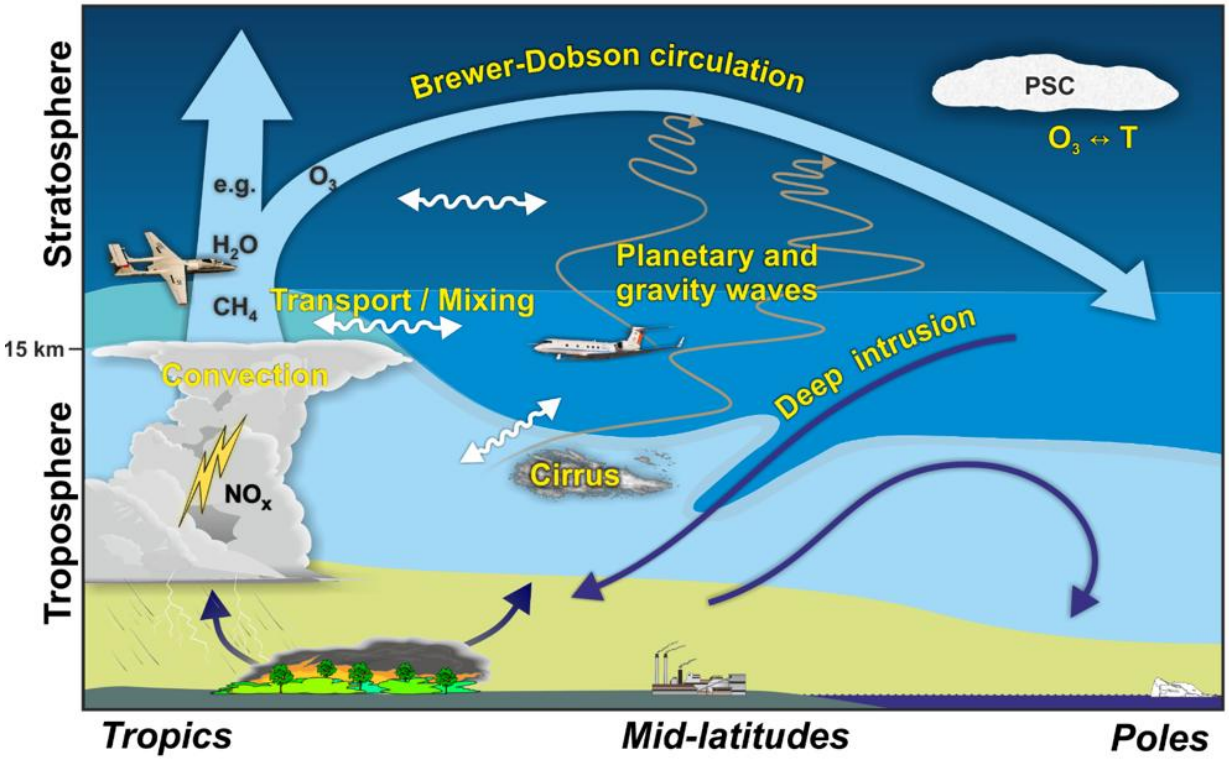




Major topics

- Stratosphere- Troposphere exchange
  - Gravity wave breaking parameterization
- Sub-grid parameterisations of fluxes for global modelling purposes
- PBL chemistry
  - Mountainous areas are distinct in terms of spatial distribution of AQ precursors
  - Influences the distribution of secondary organic aerosols and gas-phase precursors to ozone formation

Stratosphere – Troposphere Exchange



How important is the sub-grid scale for exchange of compounds between the stratosphere to the troposphere.

No parameterization for impact of gravity wave breaking for tracer transport.

Does this ***significantly*** alter the flow of chemicals from the troposphere into the stratosphere and the stratosphere into the troposphere on a regional (100km) or global scale (1000 km)?

At the moment we do not know.

Major topics

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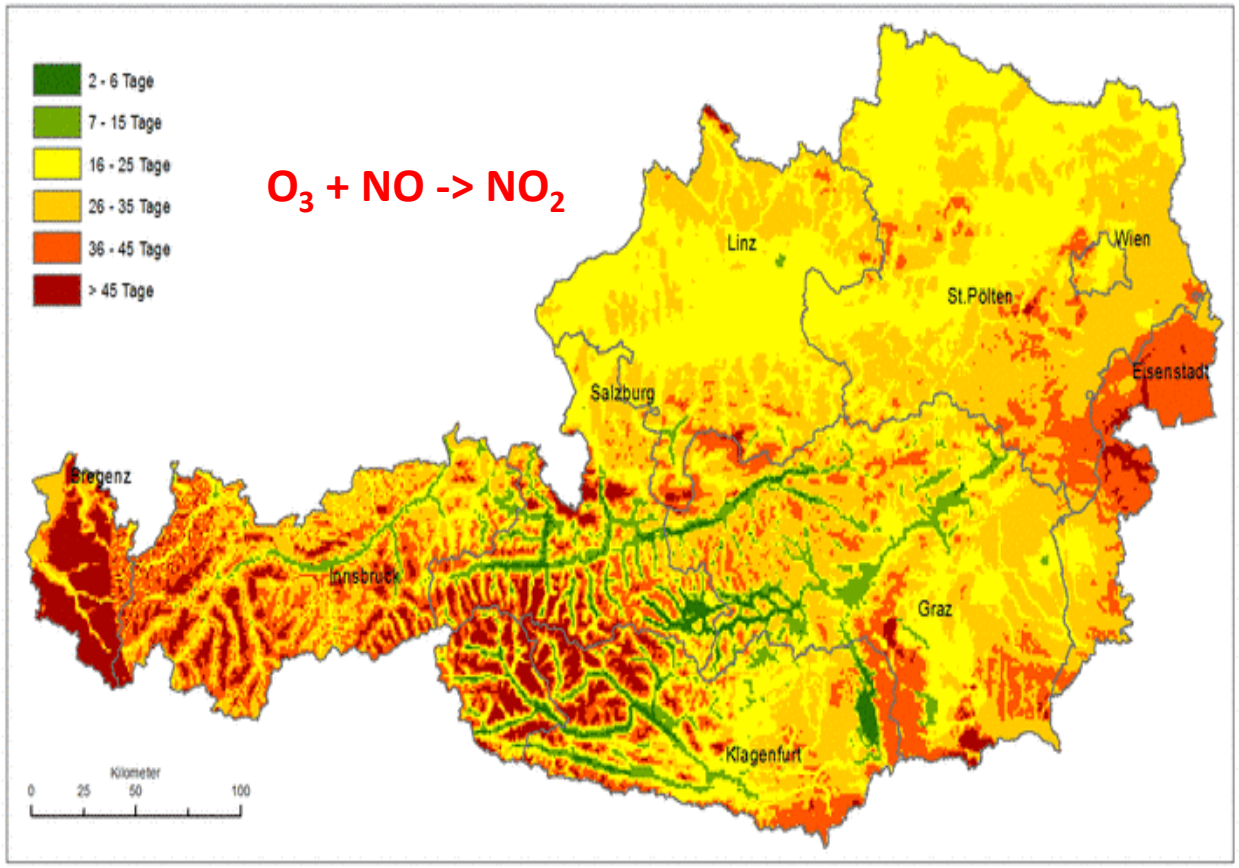
Cont..

- Spatial distribution of valley scale pollutants is important. The urban context is currently not mentioned in the White paper. How is TEAM-X dealing with the presence of urban sites and large cities located in complex topography, mountainous regions?

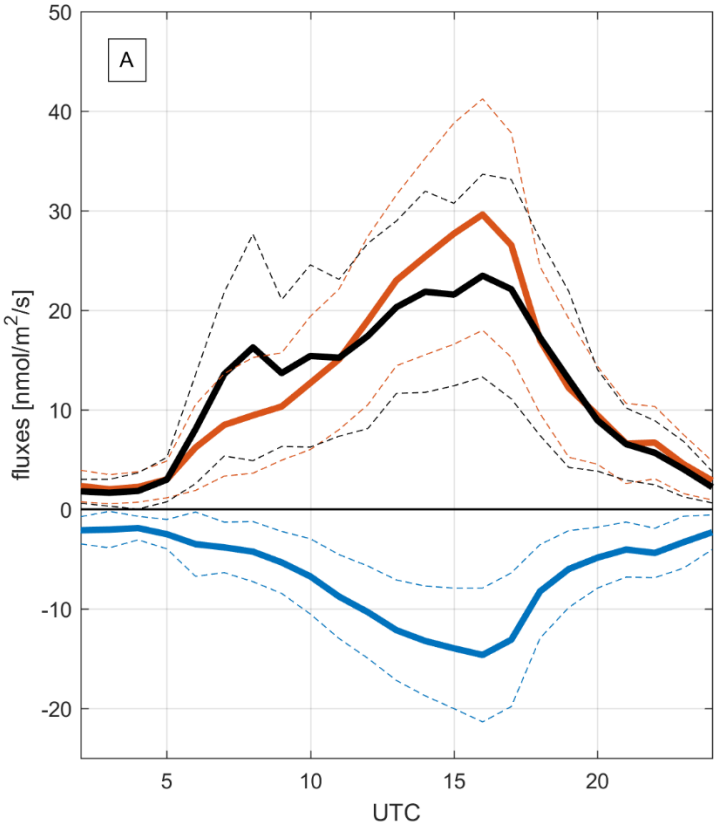
- Approx 15 Million people live in the greater Alpine region
- 20-30% of land is habitable (Alpine Convention)

Ozone in Austria

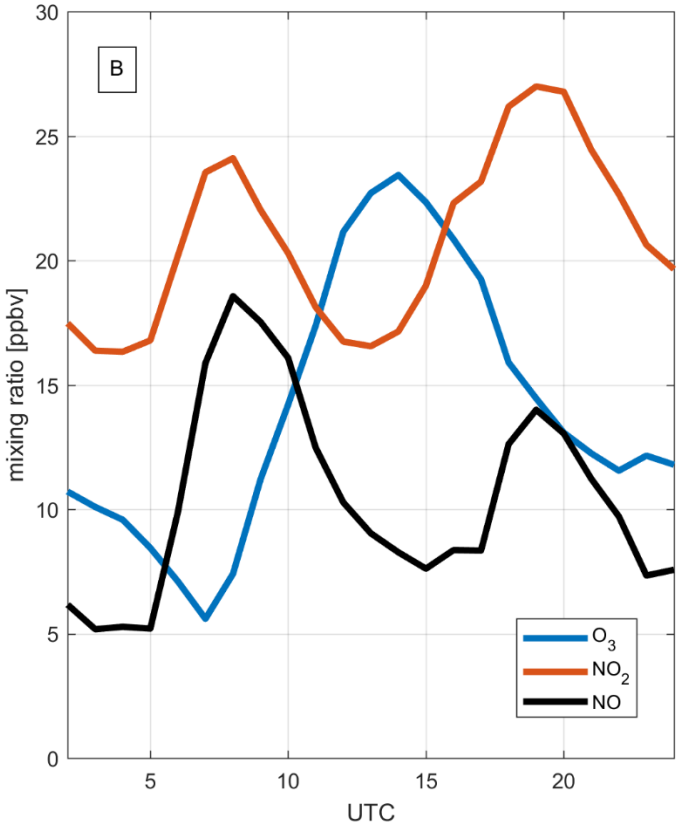


2018 O_3, NO and NO_2 fluxes

Fluxes



Concentrations



$NO_2 + h\nu \rightarrow NO + O$ (1)

$O + O_2 \rightarrow O_3$ (2)

$NO + O_3 \rightarrow NO_2 + O_2$ (3)

Urban NO_x – O_3 triad

Air pollution aspects in mountainous terrain cont.

- Approx 15 Million people live in the greater Alpine region
- 20-30% of land is habitable ->
  - High urbanization along valleys (high emission 'line' sources of NOx and aerosol precursors
  - High biogenic emissions of VOC along valley slopes

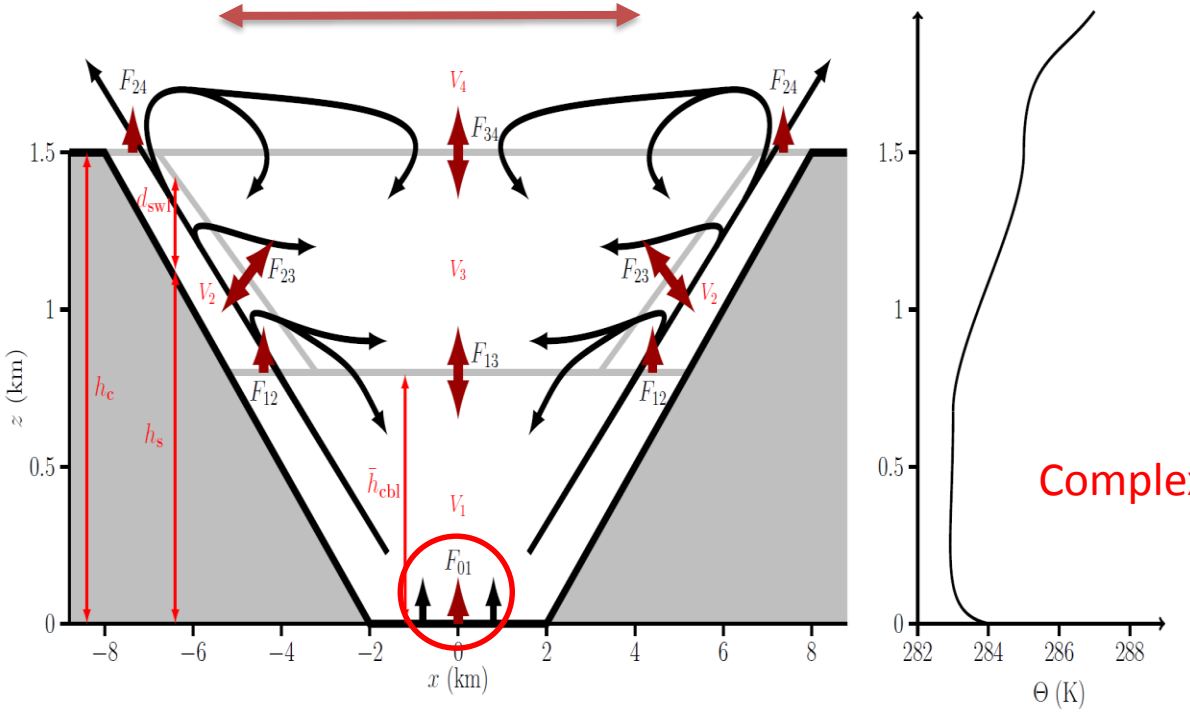
- The spatial separation is unique and valley circulation systems play an important role

- Identified two important pollution scenarios:
  - Aosta valley: advection of pollutants in classic plain-valley system
  - Inn valley: mostly local pollution and re-circulation patterns

Air pollutants trapped in a Valley

Typical GFS resolution

ECMWF resolution



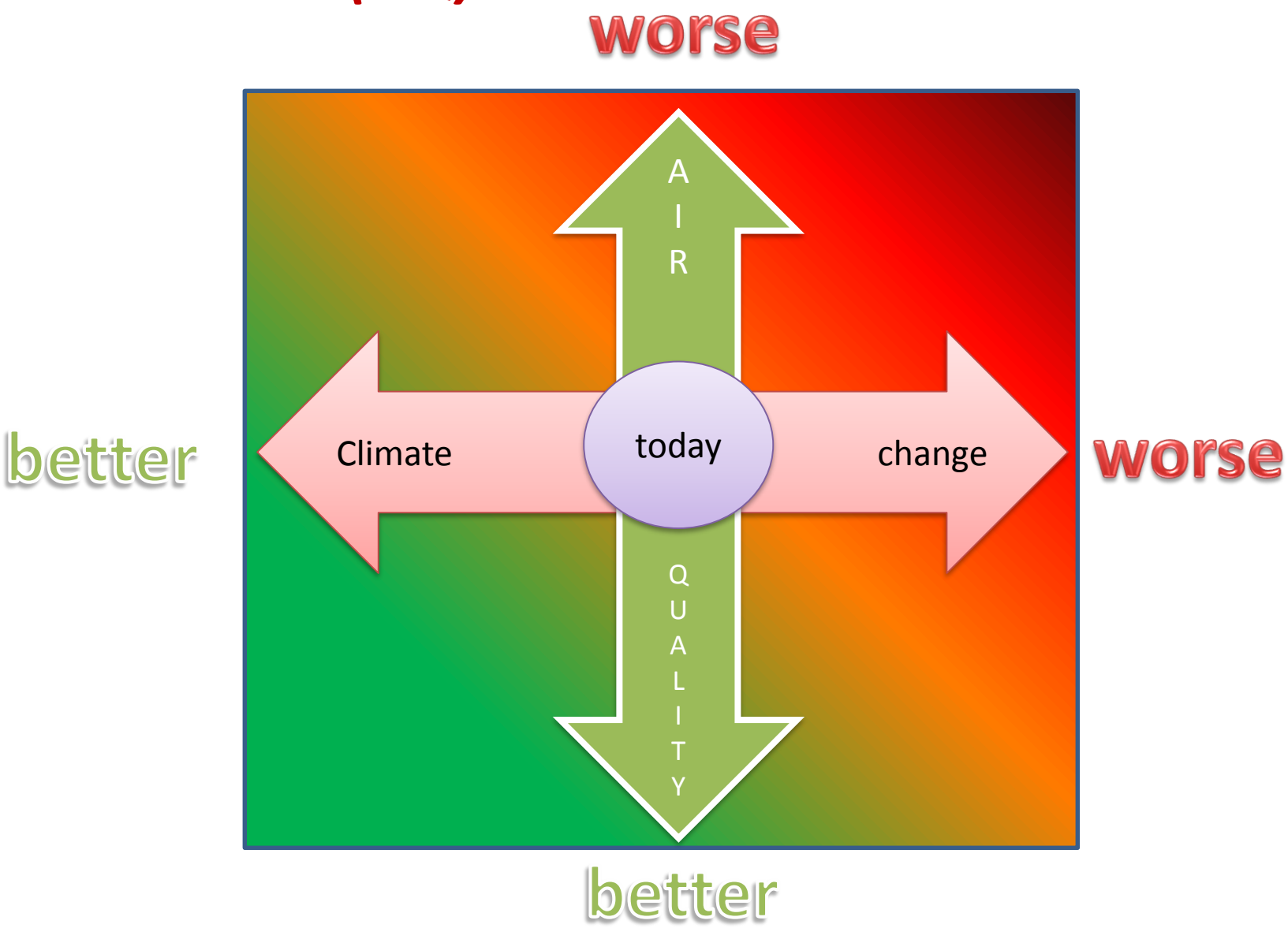
Complex recirculation patterns

Leukauf et al., Atmos. Chem. Phys., 16, 13049-13066, 2016

more comments:

- Slope winds are important for the transport of pollution but hard to resolve. Especially multiple day recirculation patterns.
- High resolution modeling has a problem with resolution when parameterizations start to fail at the high resolution end. Treatment and parameterizations of physical processes in models may become inappropriate (e.g. turbulence closures; chemistry turbulence terms, etc.)
- Issues with definition of vertical and horizontal diffusion over varying topography
- Air pollution and meteorology might not be linked strongly enough in the current text.
- Dispersion processes, and related modelling, have their own distinct features in complex topography, and possible limitations, wich need specific assessment. Tracer experiments (?)
- In order to address aerosol pollution in a systematic fashion one needs to study gasphase precursors and primary aerosols (distinct differences in seasons)
    - Winter season: Nitrate aerosol layering (E.g. Example from Utah)
    - Summer season: how important are biogenic precursors to secondary aerosols in a moderate to high NOx regime

Science to support decisions: Climate vs Air Quality (AQ) – at a cross roads



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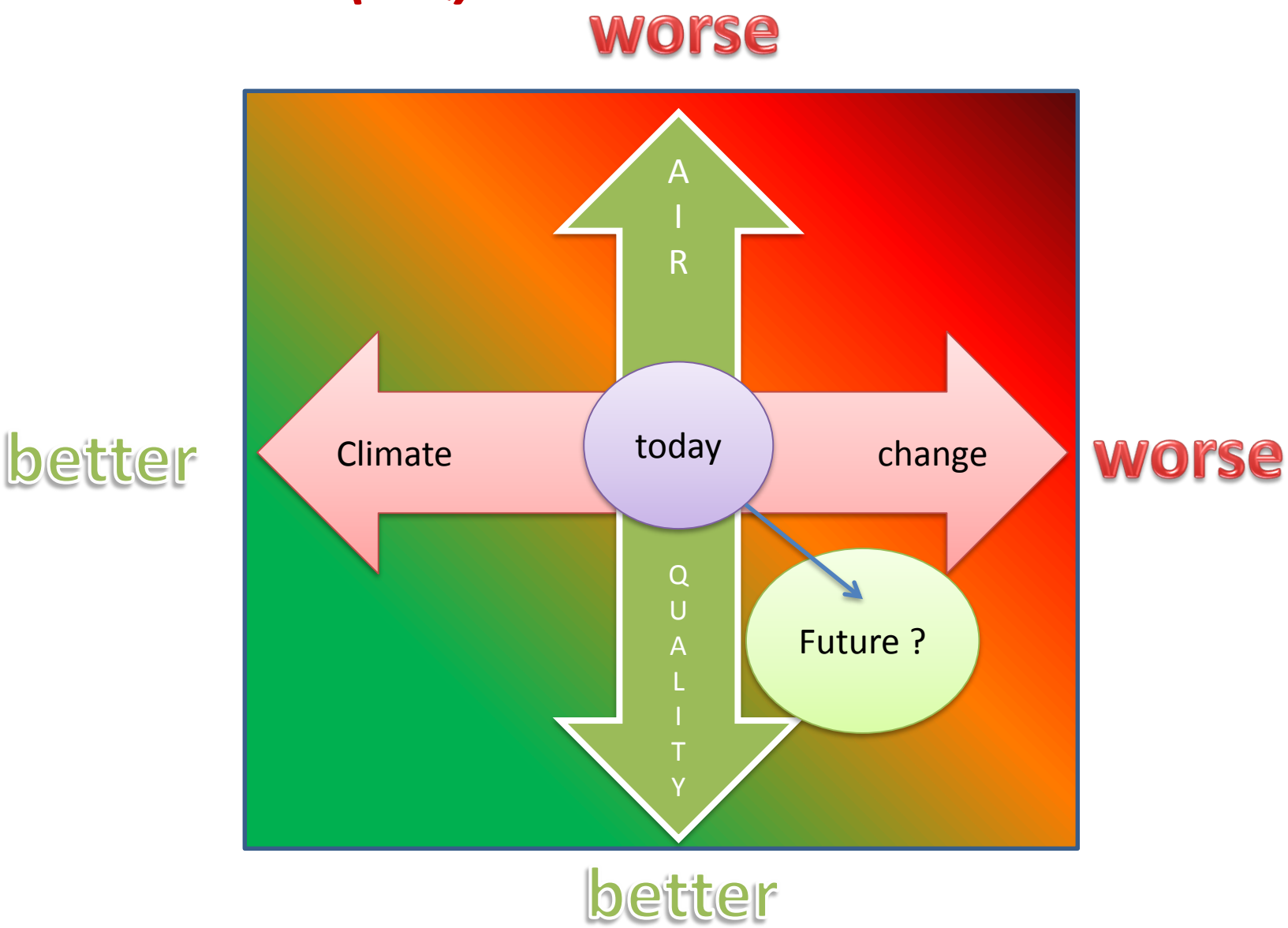

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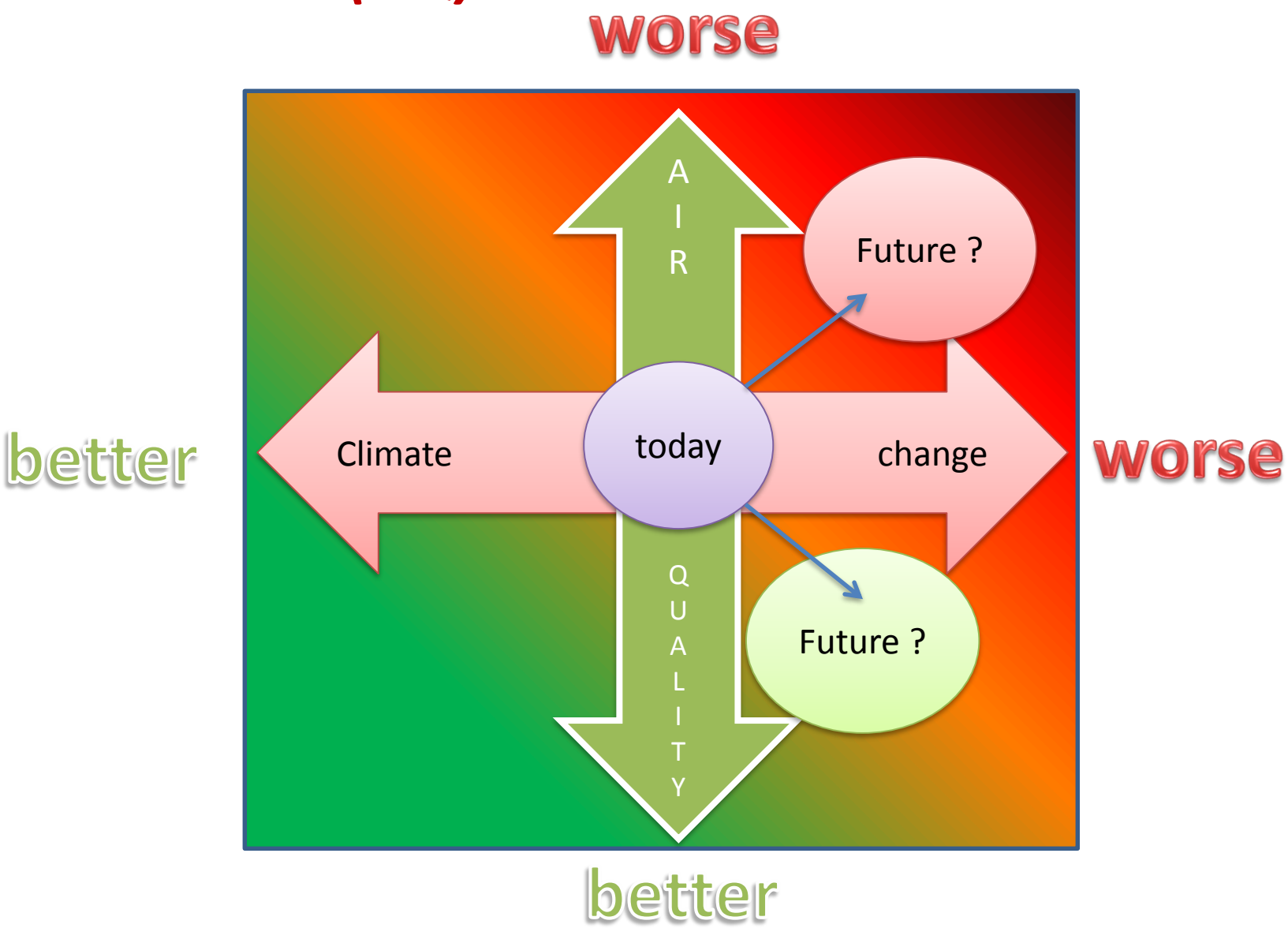

Way forward to address significant gaps?

- Flying air chemistry laboratory (requires large aircraft) could tackle significant gaps related to the 3 dim. distribution of air pollutants and their processing (e.g. better understanding of primary vs secondary aerosol)
- Spatially distributed sensor networks (E.g. affordable air quality sensors) along valleys – help better understand re-circulation patterns
- High resolution measurements (e.g. 10 Hz) suitable for eddy covariance observations (emission inventories are still one of the most uncertain parts in 3d CTMs)
- Mountain top observatories – data interpretation is often hampered by slope flows: perhaps a task for high resolution models