Flow field modelling in complex terrain using GRAMM & GUI match-to-observation

Ulrich Uhrner

Traffic & Environment Section

Institute of Internal Combustion Engines & Thermodynamics

Graz University of Technology

Contents

- Model initialisation & forcing
- Case study Salzburg St. Johann im Pongau
- Case study Salzburg Zell am See
  - 250 m x 250 m horizontal grid resolution
  - 150 m x 150 m horizontal grid resolution
- Conclusions

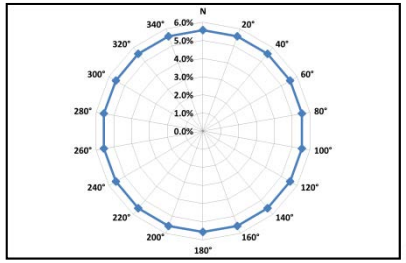
GRAMM initialisation/forcing

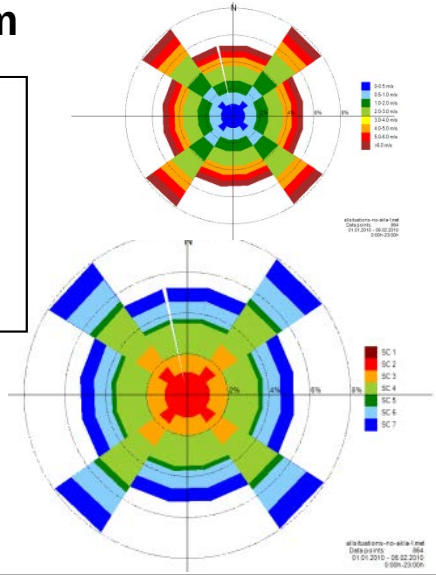
- Micro scale flow field simulations are typically strongly under-determined systems, in practice:

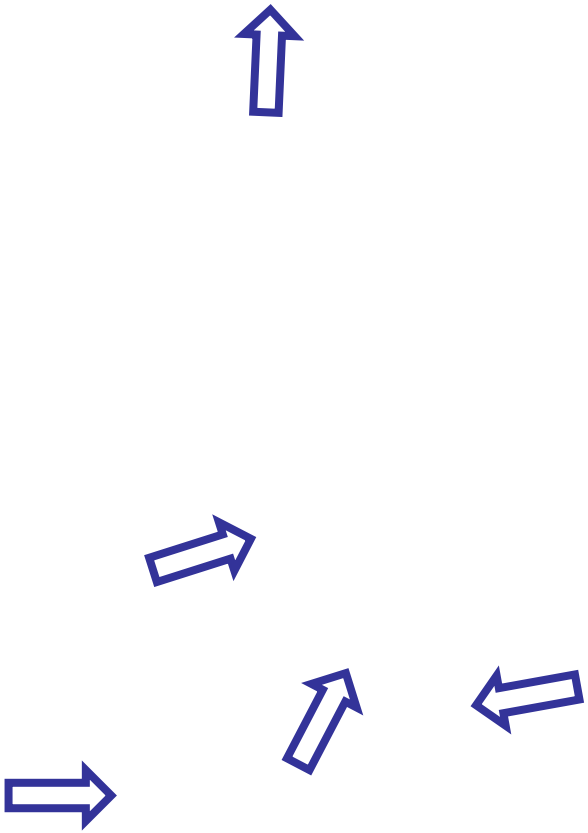
  ratio # of measurements : # grid points - 1 : 50000 to 1 : 500000
- initialisation & model forcing challenging due to uncertainties
- GRAMM initialisation & model forcing (incl. BCs) usually „bottom up“ from the surface, transfer to entire domain incl. boundaries (only in research projects „outer & top down“ or hybrid forcing, e.g. by WRF)
- Methodologies typically used:
  - Classified representative ground based measurements (wind, stability class) @ 1 location are used for model forcing
  - Simulation of a practical range of predefined triplets of classified wind sectors (36 x 10°), wind speed & dispersion classes && after simulation comparison with measurements in domain – best matching flow field is selected
- SC init & terrain impact on anabatic (up) & catabatic winds (down)

Case study Salzburg St. Johann im Pongau

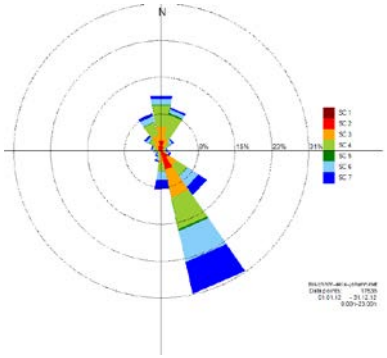
- **3 wind monitoring stations**
- **stability class wind speed, cloud cover & height obs from St. Johann (3 hrs)**
- **36 wind sectors x 7 wind speed classes x 6 stability classes (SC) from ZAMG**
- **250 m x 250 m**

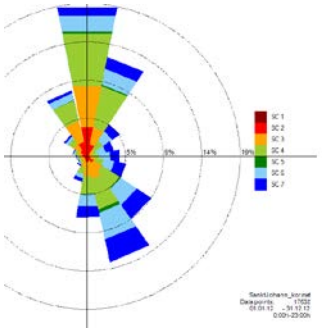


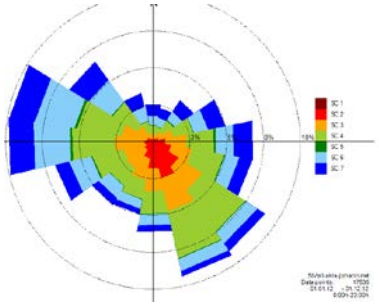




St. Johann im Pongau & processed monitoring data

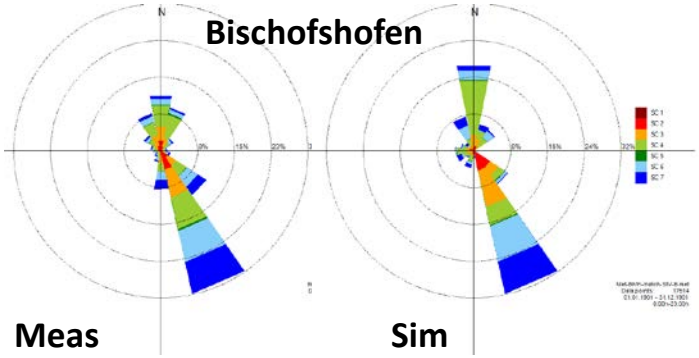


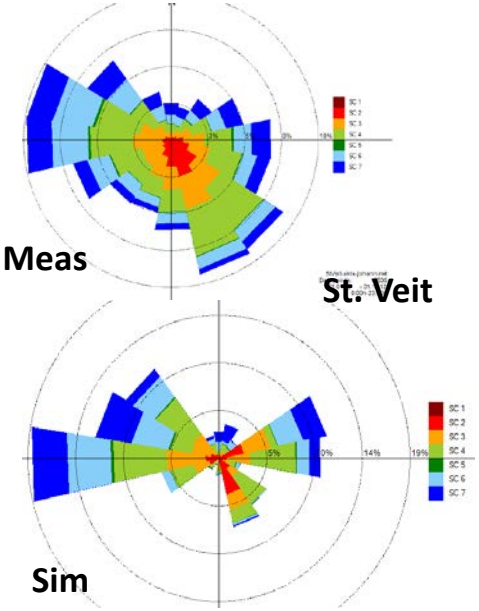


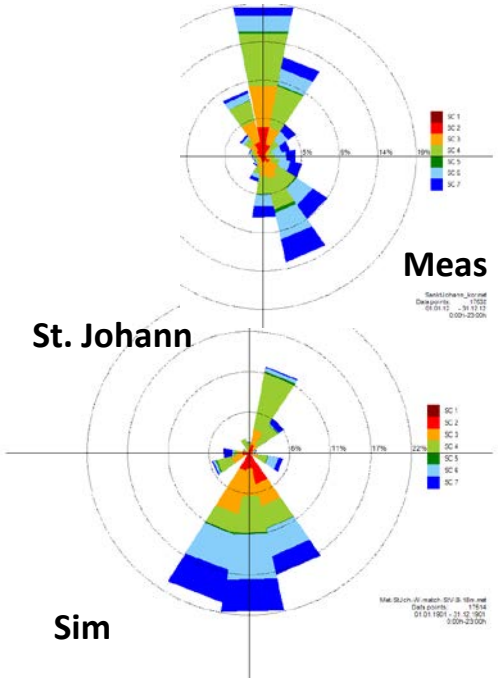


- SC trans-ferred from St. Johann to Bischofshofen & St. Veit
- St. Johann SC 1 to 3 ~ in line with anabatic flows, catabatic N‘ly strange!
- Bischofshofen anabatic S‘ly?
- St. Veit ?

Results St. Johann im Pongau
modelled vs simulated SC related wind roses

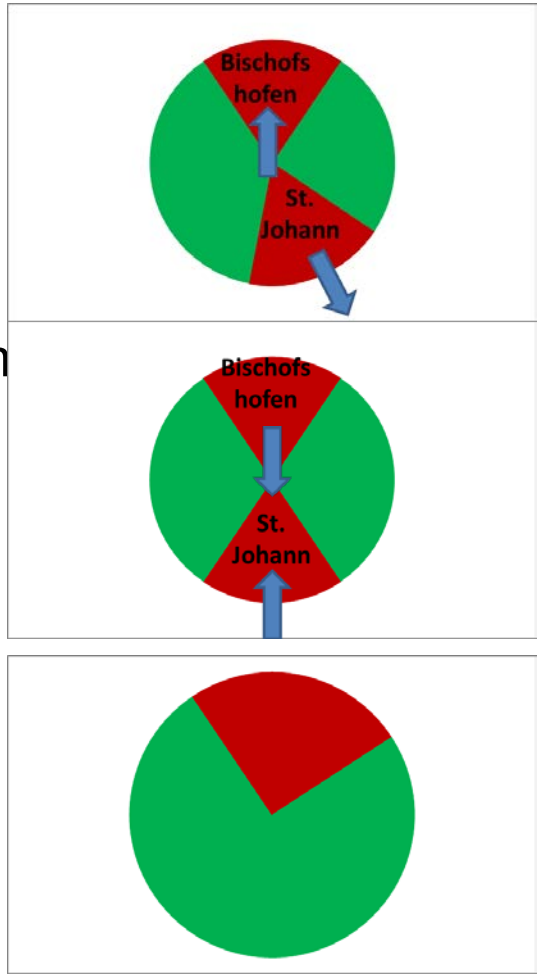




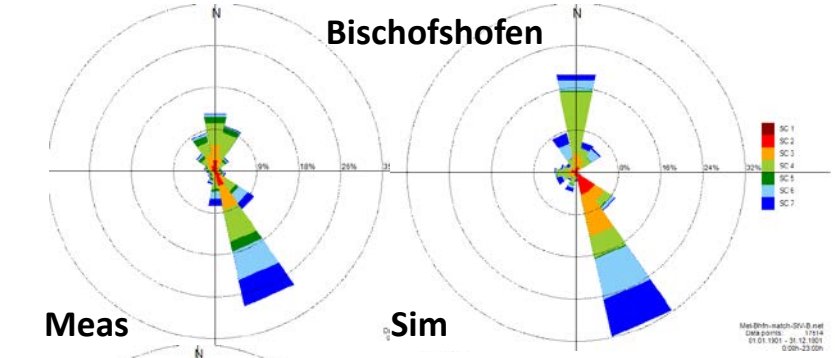


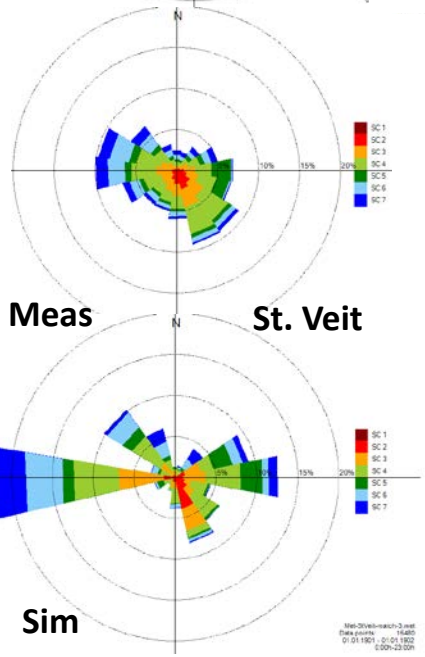
Data conflicts & corrections

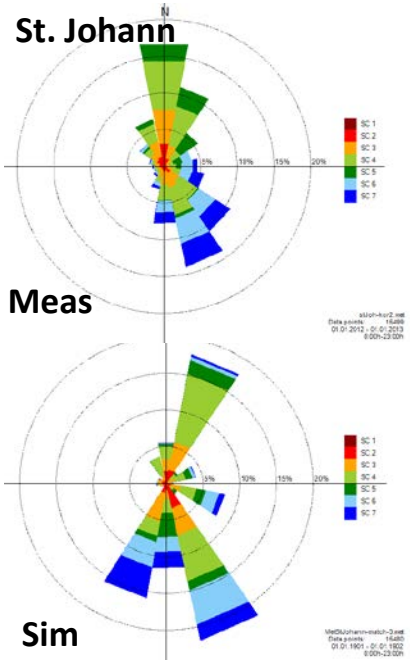
- Comparison revealed further deficiencies such as momentum, diurnal cycles wind direction, particularly flow fields
- Closer look at time series in wind direction Bischofshofen & St. Johann revealed several opposed winds (11.6% of all measurements which were taken out)
- SC corrections St. Johann: 7 & 6 set to 5 if upvalley wind from 325° to 55°
- St. Veit – different location, potential conflicts less obvious - no changes



St. Johann im Pongau with corrected forcing modelled vs simulated SC related wind roses

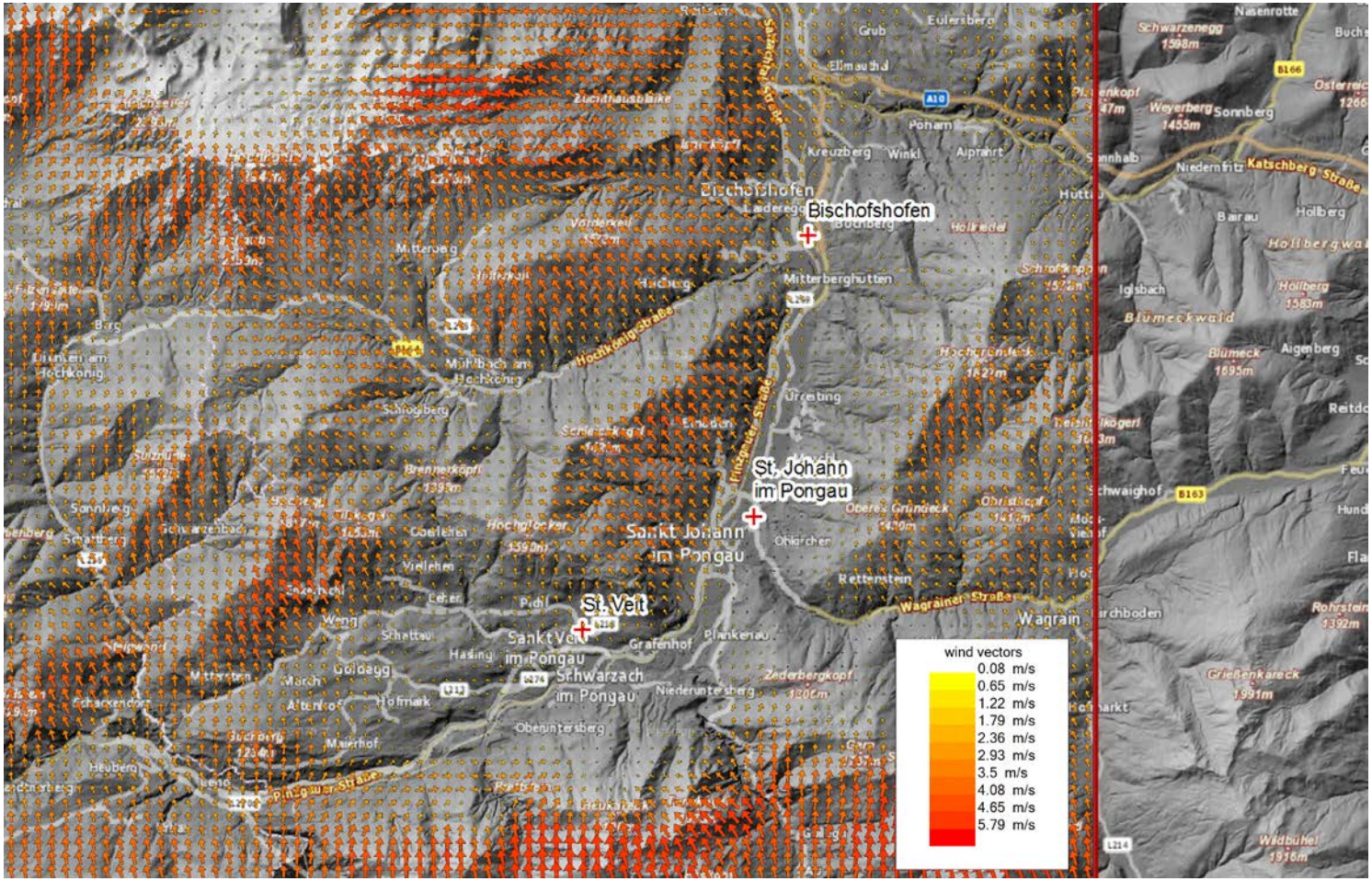




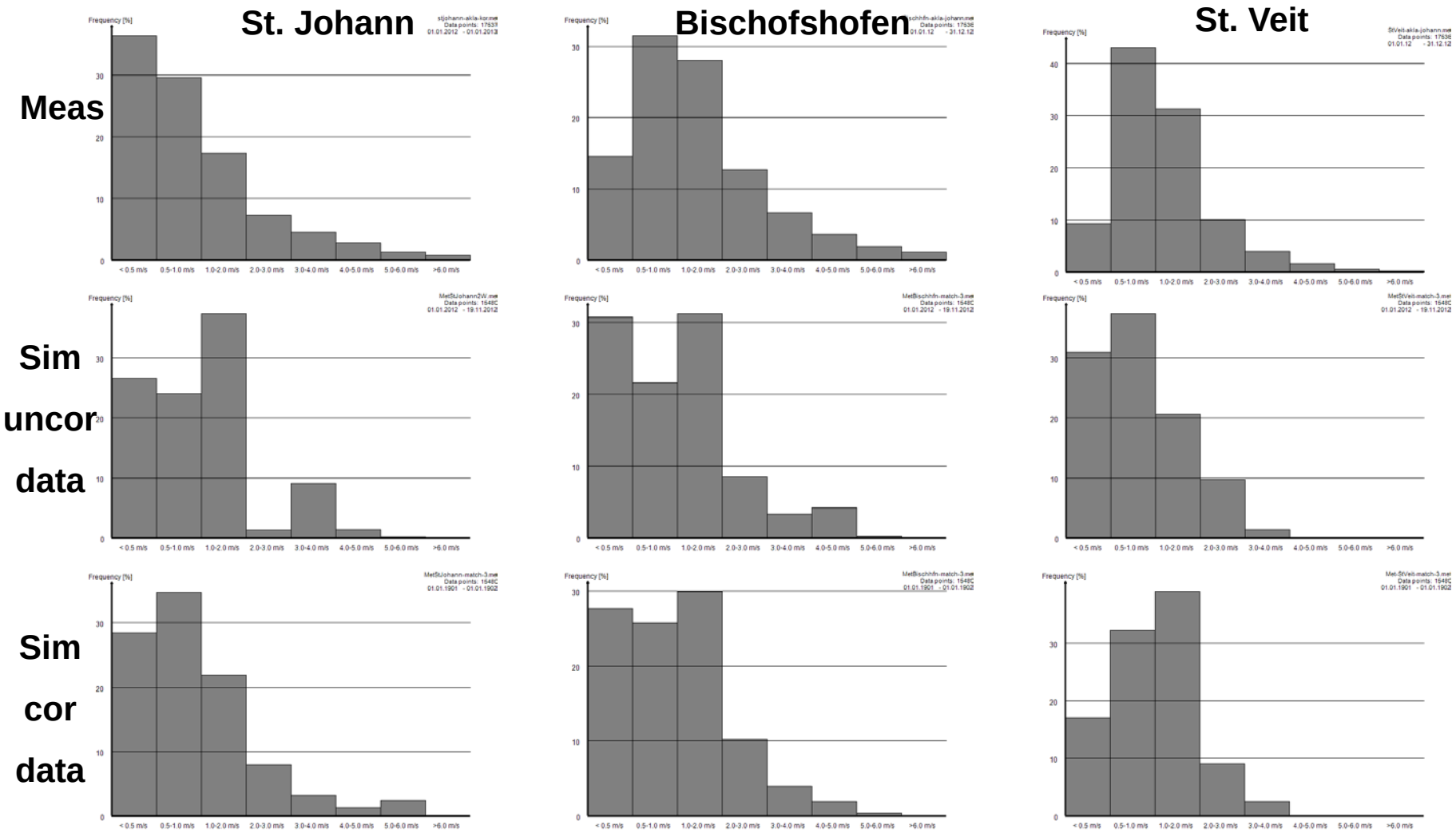


St. Johann - flow field example catabatic flow after match-to-obs (re-ordered)

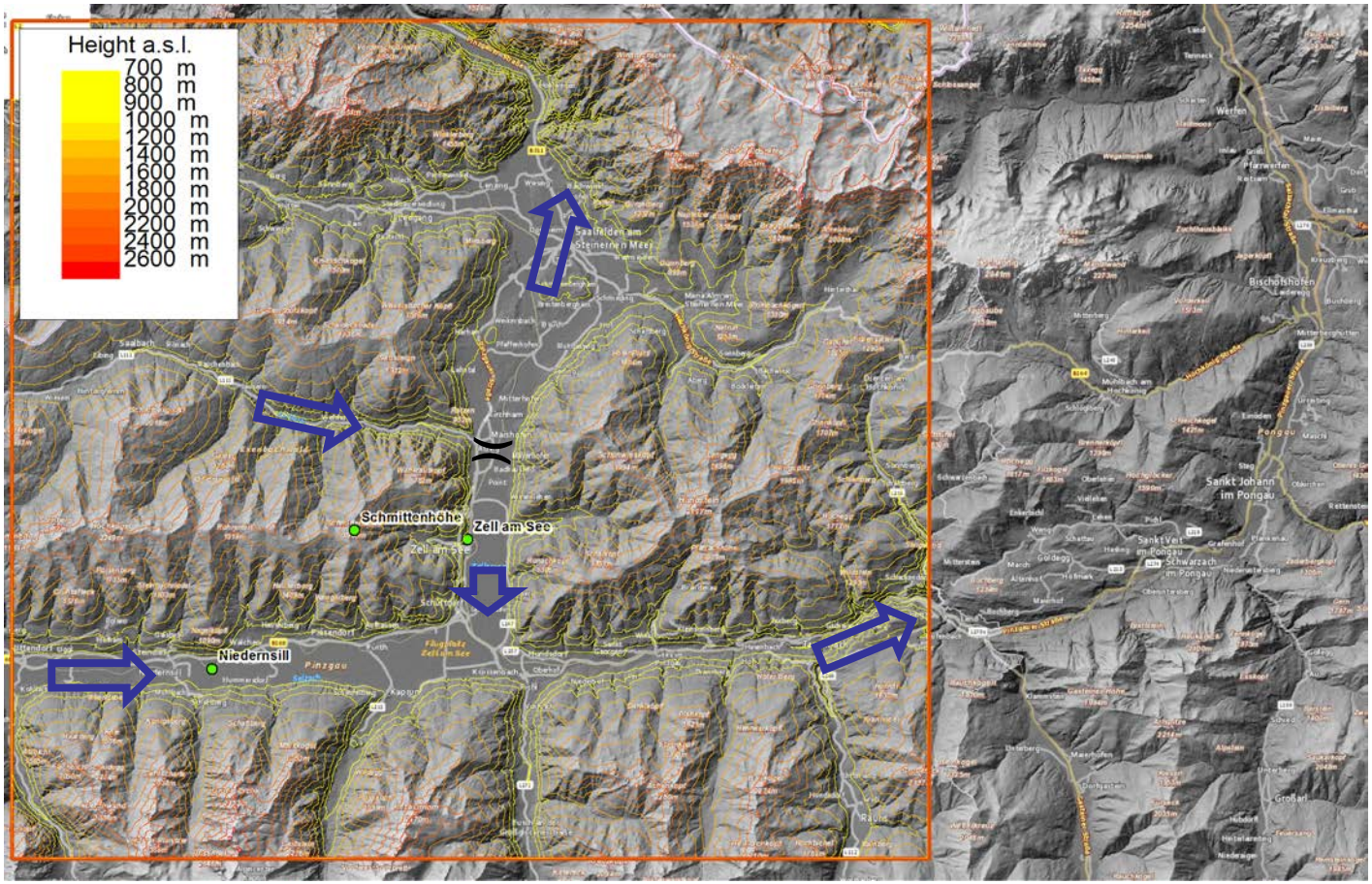
Flow field after match-to-obs (re-ordered)
SSE, 1.5 m/s, SC 2



Comparison wind speed classes

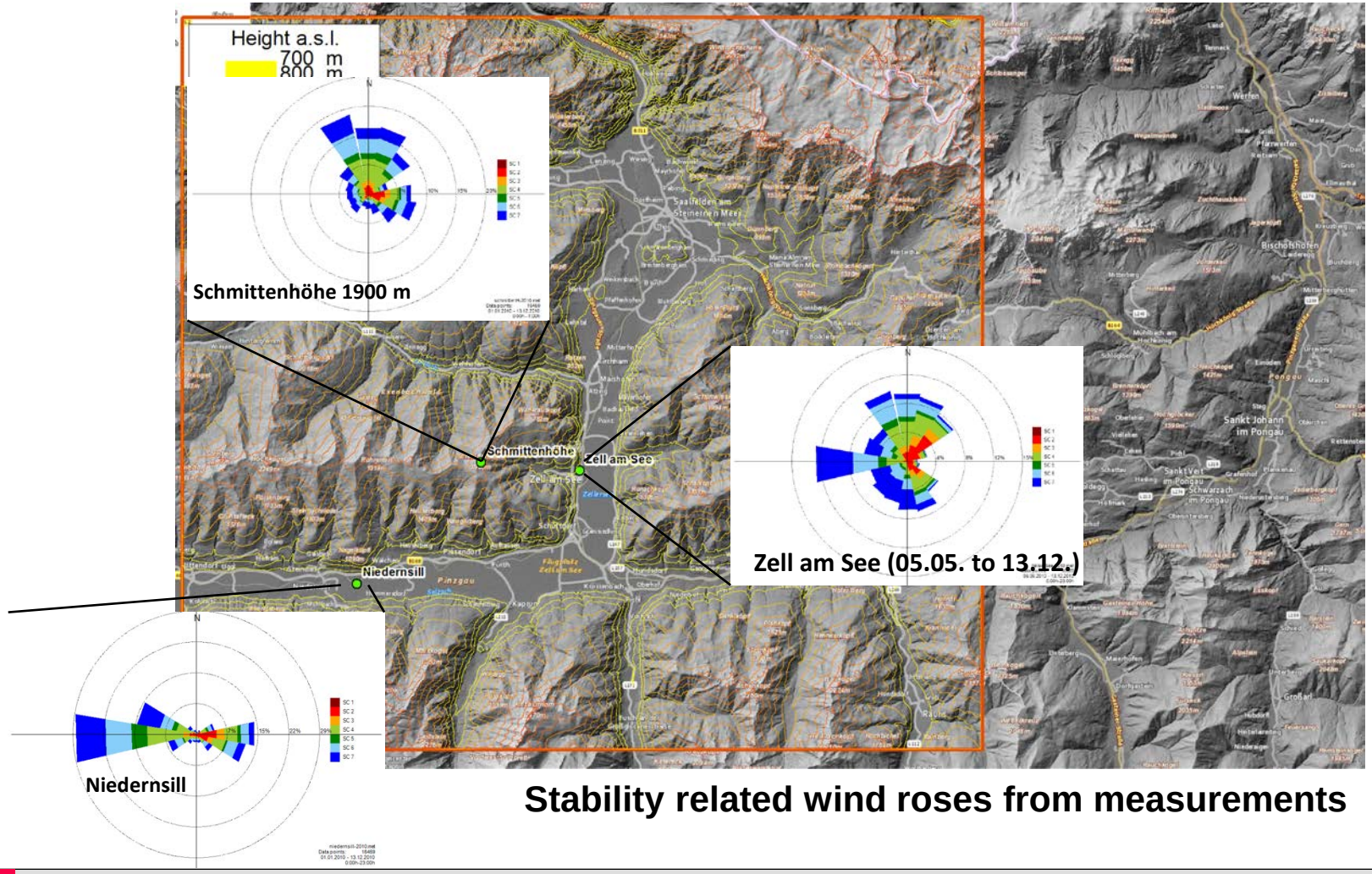


2nd case study Salzburg Zell am See
⊥ shaped valley structure



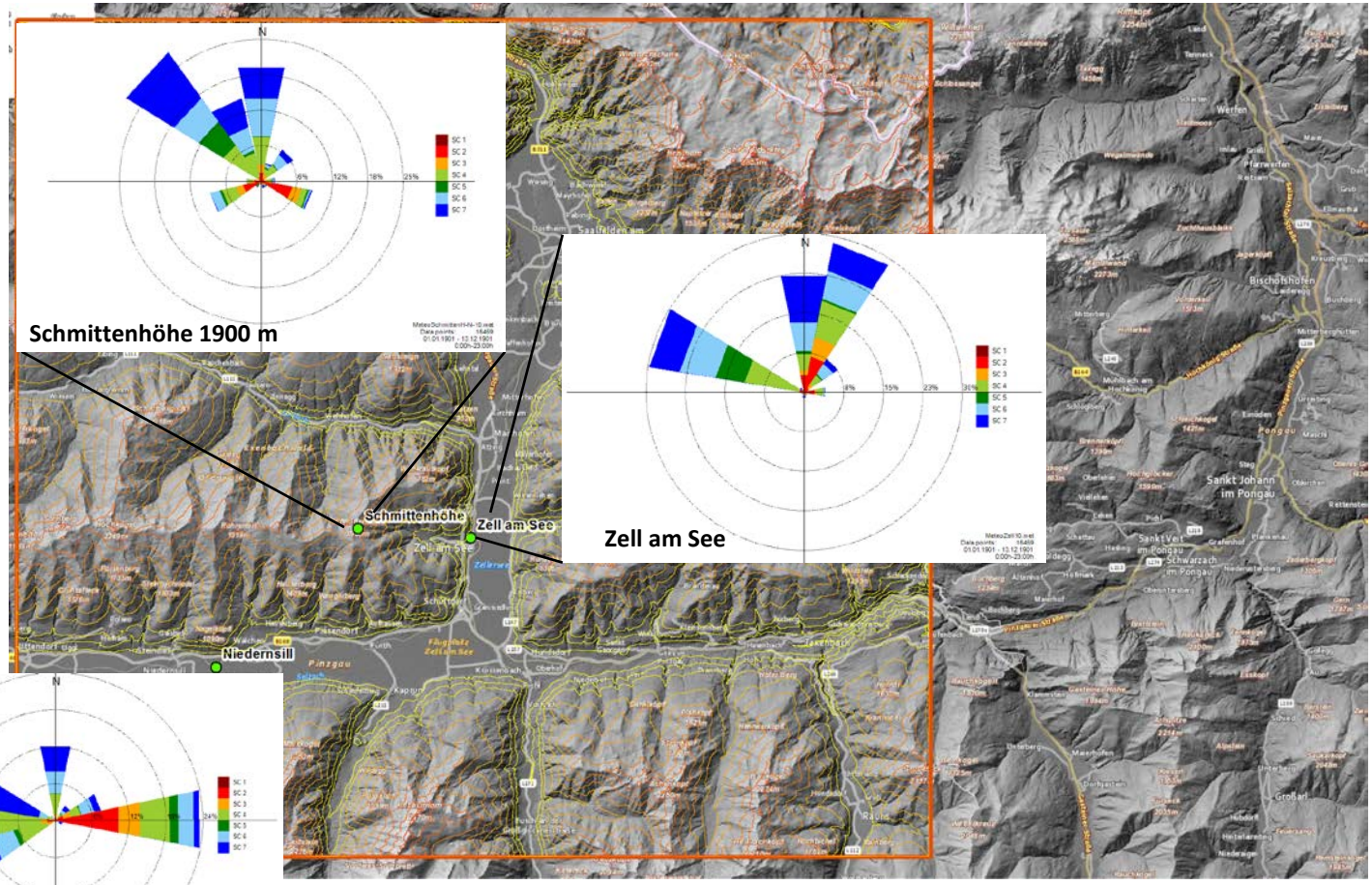
- 3 wind monitoring stations
- Dispersion class based on radiation budget from Niedersill
- 36 wind sec x 7 WS x 6 disp classes
- match-to-observations approach
- 250 m x 250 m & 150 m x 150 m

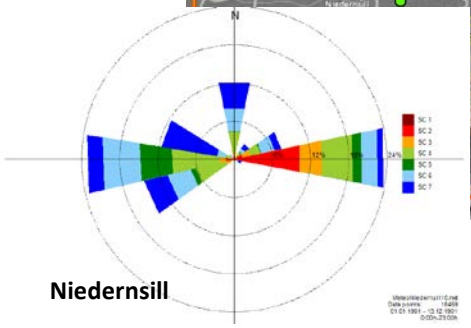
Salzburg Zell am See & processed monitoring data



Stability related wind roses from measurements

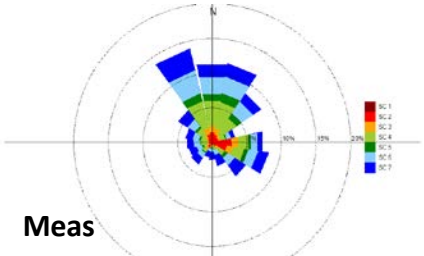
Results Salzburg Zell am See
Modelled SC related wind roses 250 m x 250 m





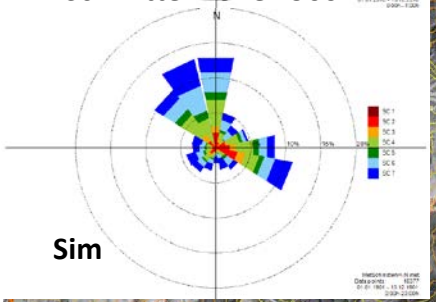
Modelled wind roses 250 m x 250 m with match-to-observation

Results Zell am See
150 m x 150 m

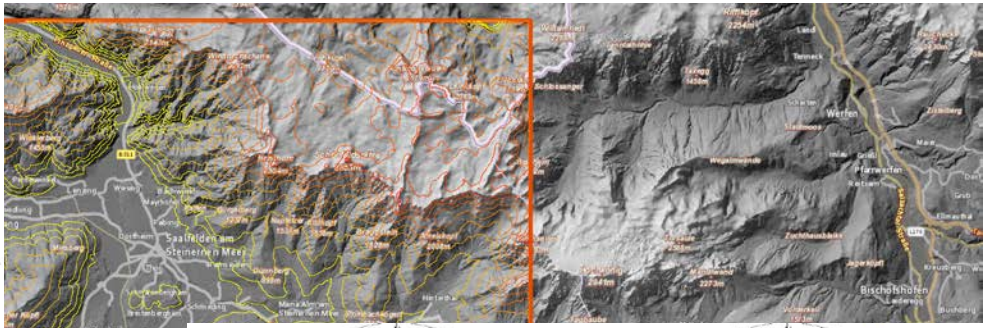


Meas

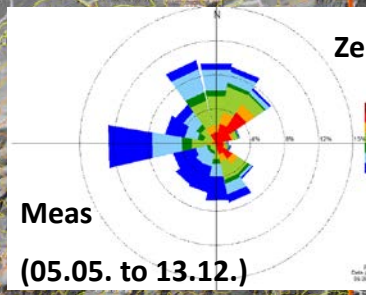
Schmittenhöhe 1900 m



Sim

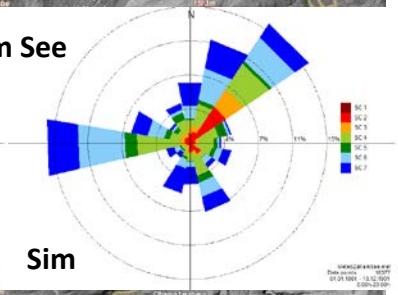


Zell am See

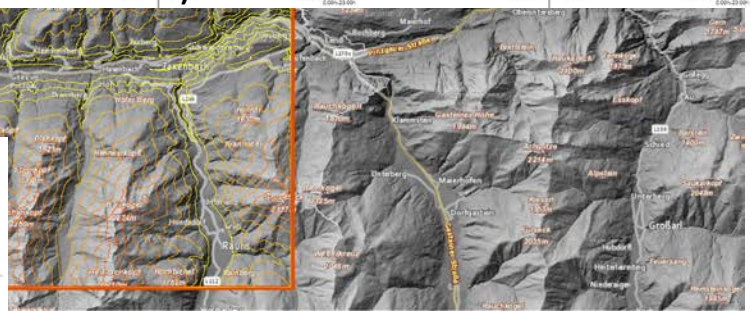


Meas

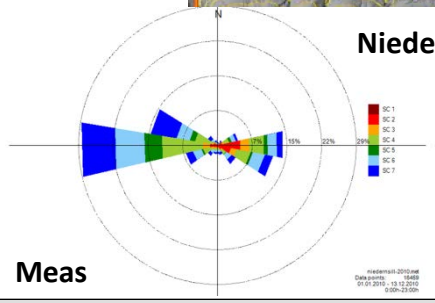
(05.05. to 13.12.)



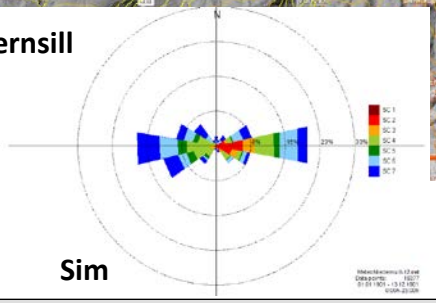
Sim



Niedernsill



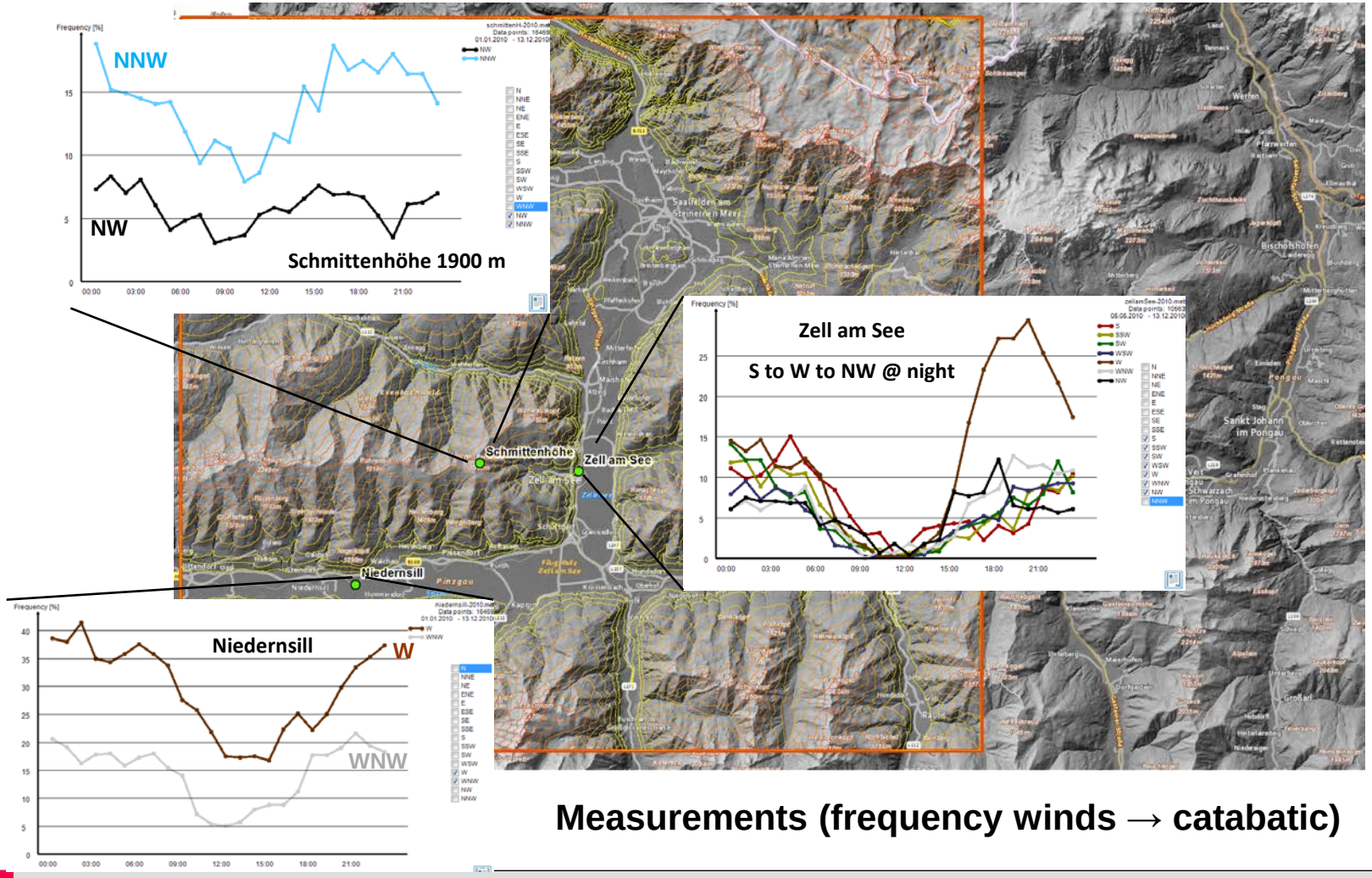
Meas



Sim

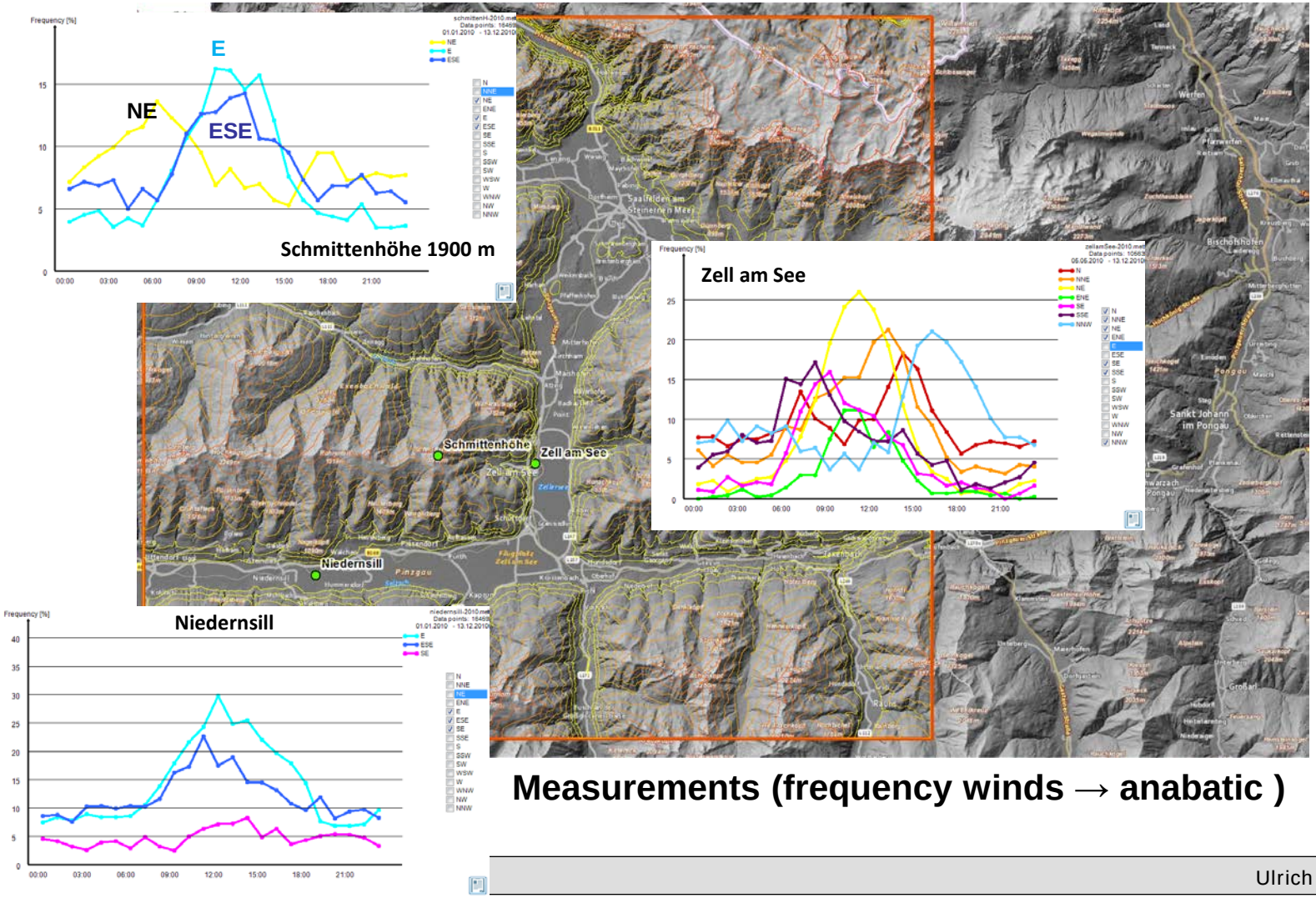
Modelled wind roses 150 m x 150 m with match-to-observation

Salzburg Zell am See & measured diurnal wind cycles with Max at nighttime



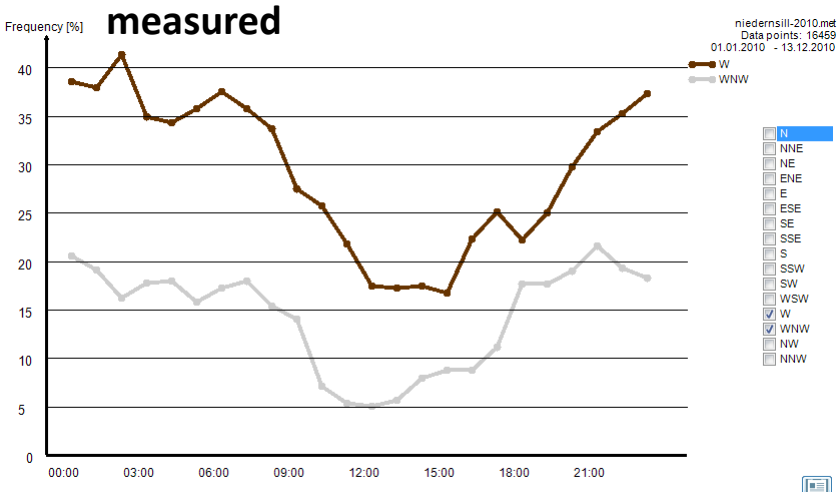
Measurements (frequency winds → catabatic)

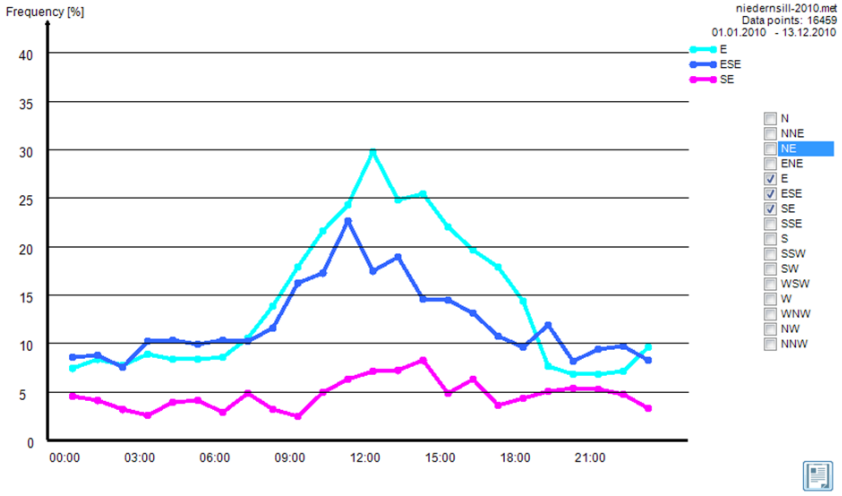
Salzburg Zell am See & measured diurnal wind cycles with Max at day time

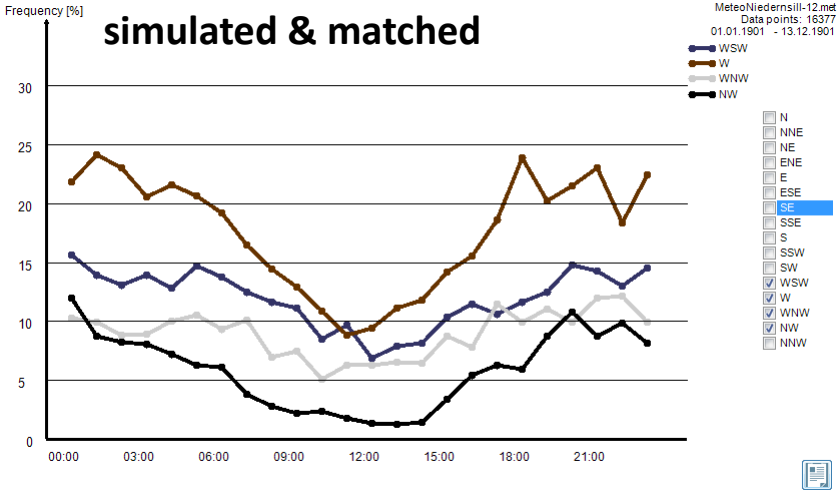


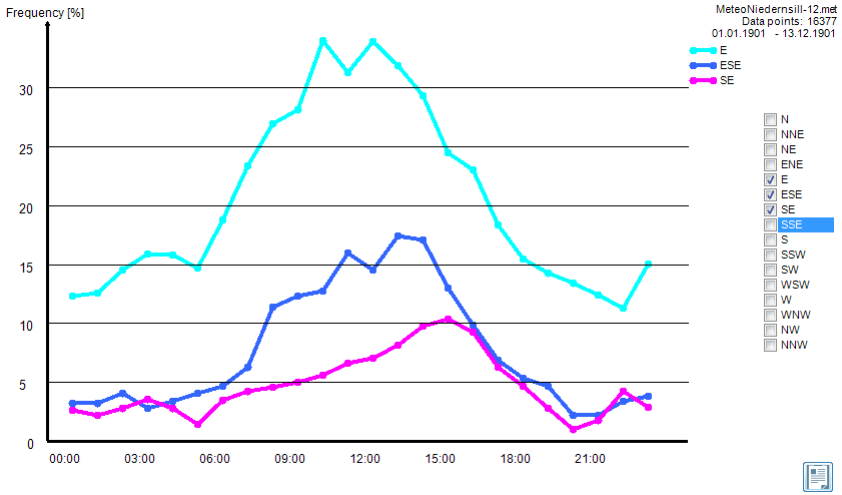
Measurements (frequency winds → anabatic)

Niedersill measured wind dir cycles vs simulated ones

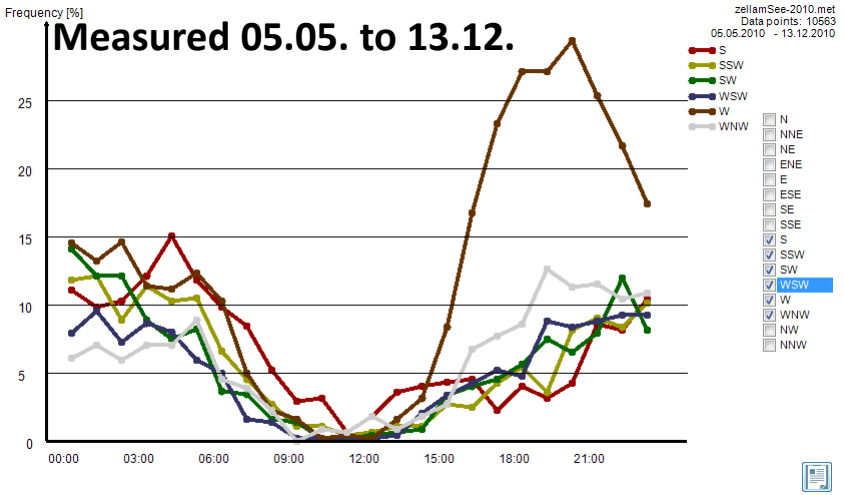


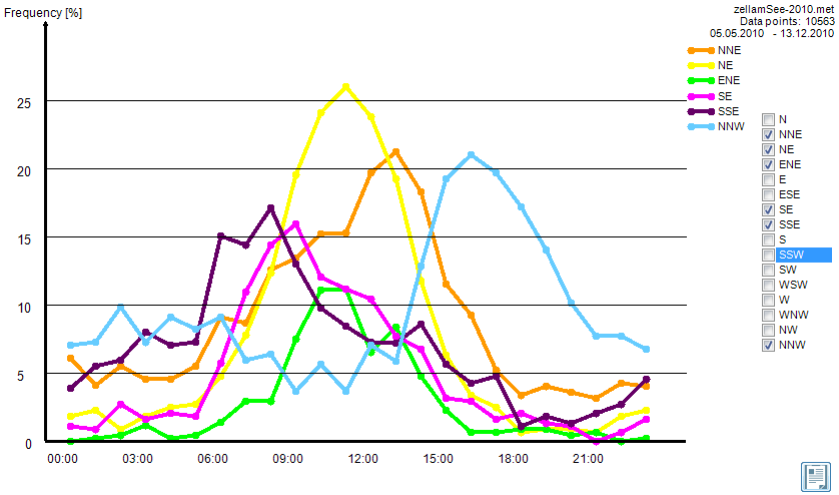


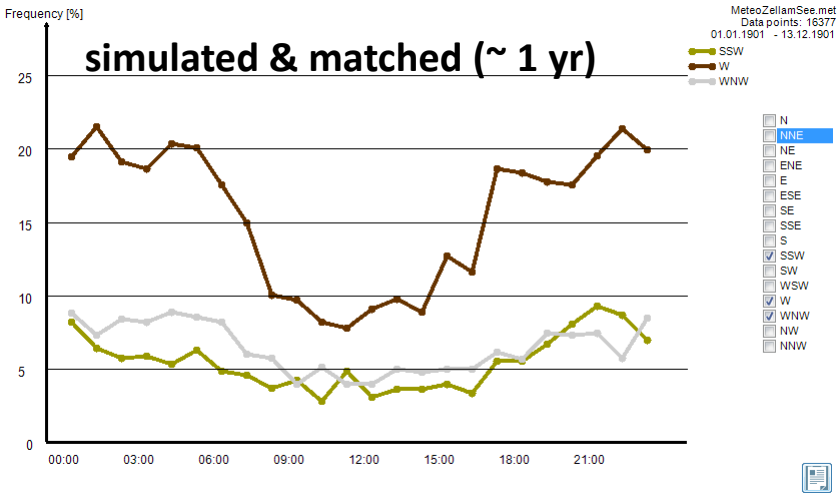


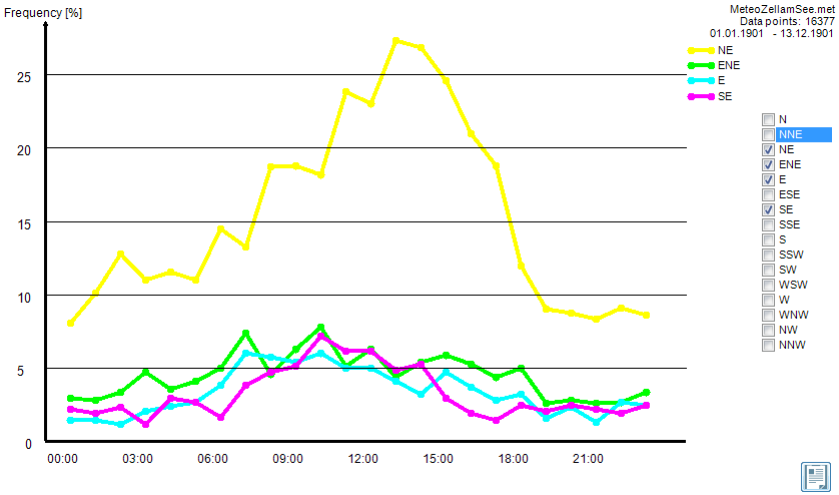


Zell am See measured wind dir cycles vs sim ones

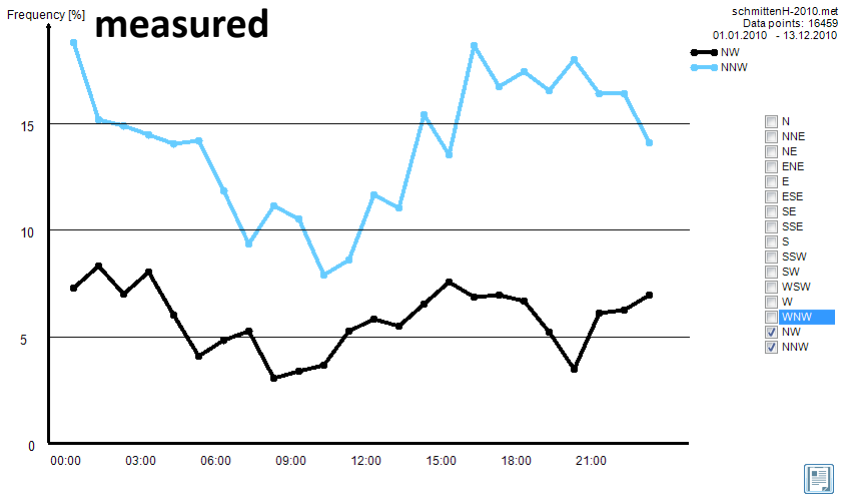


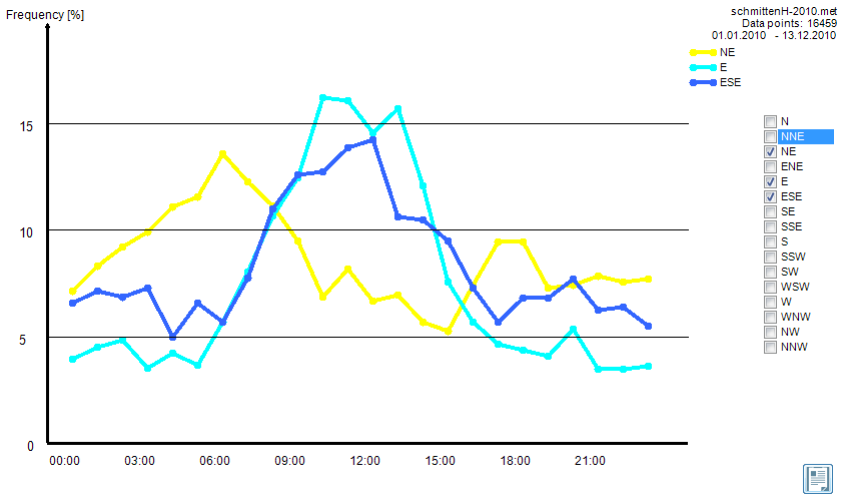


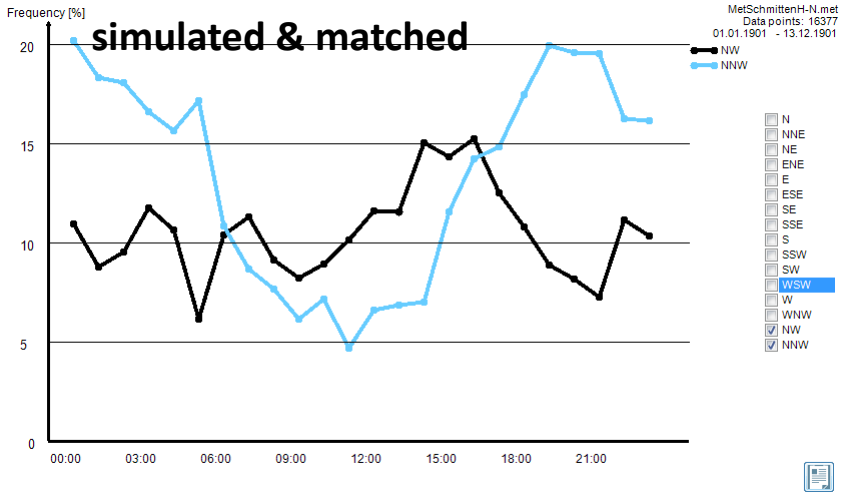


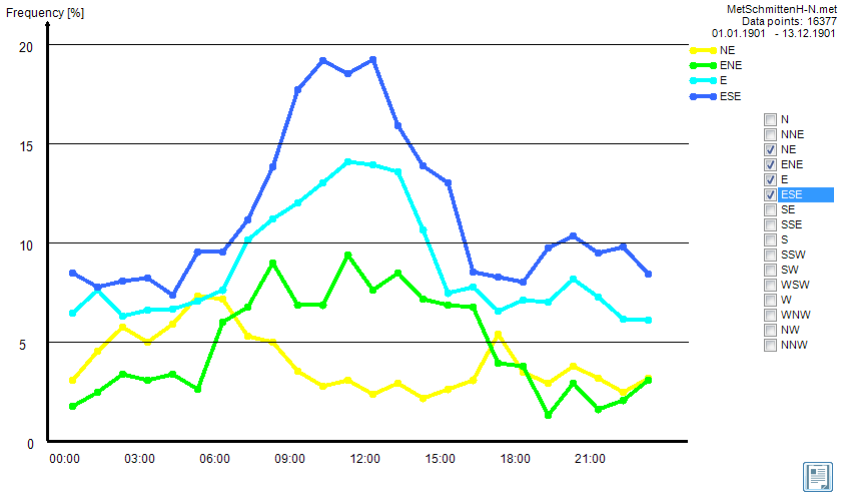


Schmittenhöhe measured wind dir cycles vs sim ones





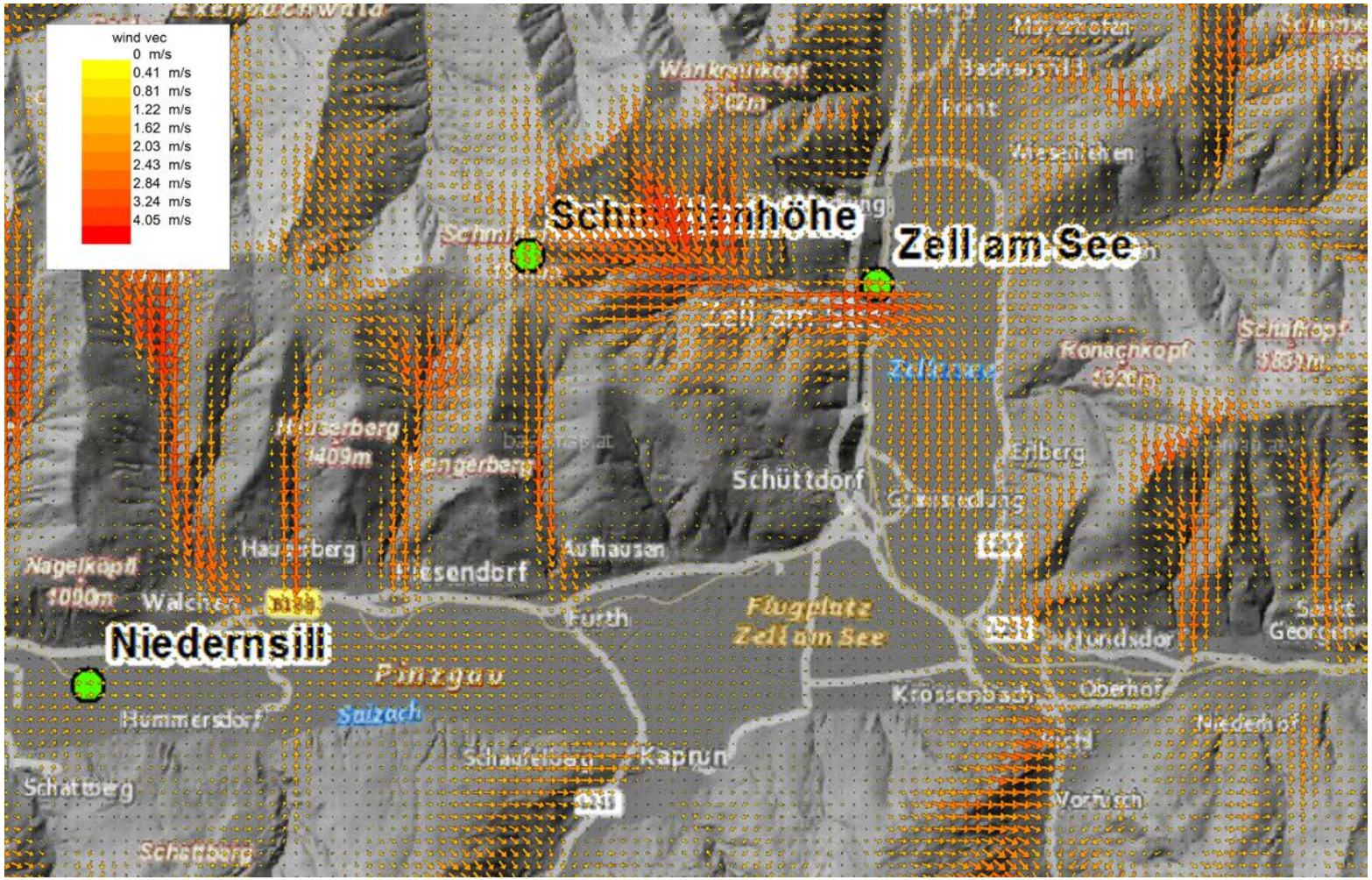




Flow field after match-to-obs (re-ordered)
NNE, 0.8 m/s, SC 6

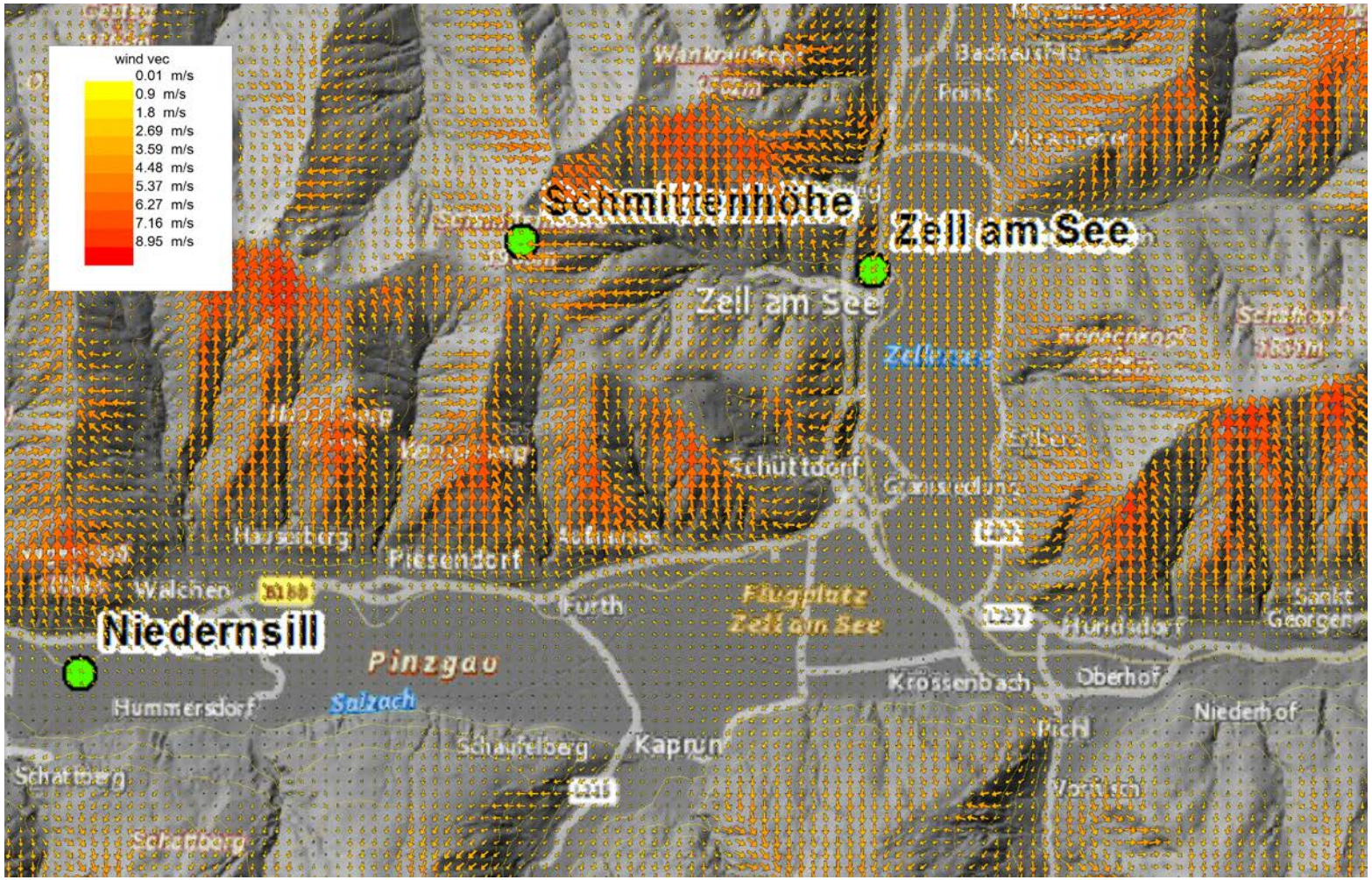
Example flow field after match-to-obs (re-ordered) W, 1.5 m/s, SC 6

Flow field before match-to-obs
N, 0.8 m/s, SC 6



Flow field after match-to-obs (re-ordered)
NNE, 1.5 m/s, SC 2

Flow field after match-to-obs (re-ordered)
S/SSW, 1.5 m/s, SC 2



Conclusions & Discussion
Flow field modelling in complex terrain using GRAMM

- Measurements & Classification concept (Init/Forcing/Matching)
  - Methodology of classification in complex terrain
  - Adaptations or transfering SC - further experimental evidence required
  - Wind direction (valley/slope wind systems) as proxies for e.g. PGT?
- Adequate representation of governing physical processes (independent of methodology used)
  - Slope vs. valley wind systems vs. compensating winds (across valley winds) vs. synoptic scale flow
  - Resolution matters!
  - Steady state approach & classification has severe limitations (time information is lost

Conclusions
Flow field modelling in complex terrain using GRAMM

- Post-processing by match to observation
  - Match-to-Observation smart approach
  - flow field (wind vectors) results partly not plausible
    - Related to re-ordering?
    - Stability information (SC) retained?
    - nice results for the wrong reasons may result but we want to use these flow fields as subsequent input for dispersion computations

Thank you for your attention!
(uhrner@ivt.tugraz.at - +43 316 873-30220)