Reliability of current CFC data for age dating of water

Pablo Dávila and Christoph Külls

HYDROLOGY

PROBLEM

Dissolved Concentrations

CONDITIONS:
Temp. = 20° C,
Altitude = 600 m.a.s.l.,
Salinity = 2 ‰.

CFC-11
CFC-12
CFC-113

(*) Source : USGS

PRESENT SITUATION OF WATER AGE DATING WITH CFCs
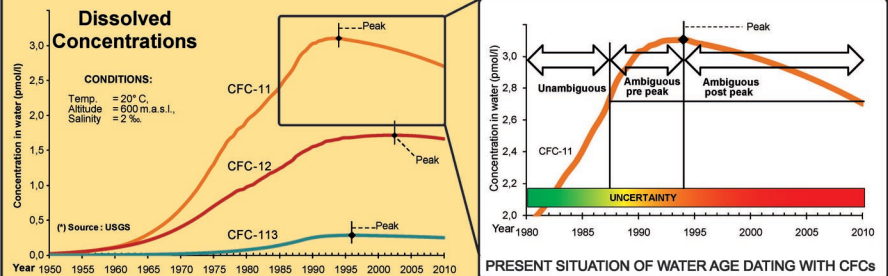
RESEARCH QUESTIONS

Can we extend the use of CFCs as tracers in the hydrological system?

Are there methods that reduce uncertainty in the analysis of residence times?

BACKGROUND

CFC tracers used for water age estimation decrease. Their application in research is expected to be more limited in future.

We have investigated methods to extend application of CFCs and to quantify uncertainty as a function of time.

CURRENT METHODS

Comparison of known atmospheric inputs with CFCs, SF_6 and SF_5CF_3 with measurements from samples.

CONCLUSIONS

To reduce the ambiguity in water age studies, due to the decrease in CFC concentrations, different approaches for data analysis are proposed.

If it is possible to identify the type of mixing model (Exponential Model, Dispersion Model), uncertainty can be reduced and the age dating of water with CFCs can be extended.

In future water age estimations with the use of CFCs as tracers need to be made with a model optimization and including uncertainty.
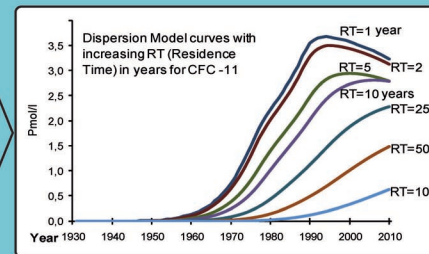
Identified options for water age dating studies
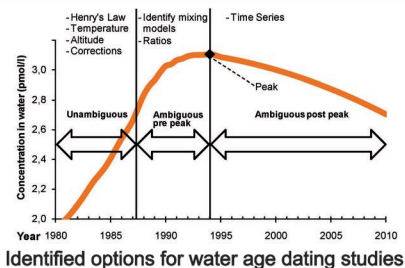
PROPOSED METHOD

Use of different models

Explore data with different transport models: test exponential and dispersion models.

Provide aditional data, that would help to identify the best fitting model for each particular case.

Alternative data analysis (RATIOS)

Evaluate a combination of ratios of CFCs, SF_6 or SF_5CF_3 and input, to seek a differentiation of the curve and a measured sample.

This technique could be used as an approach to reduce the present uncertainty of measurements.

Time series analysis and mixing

Resampling of boreholes can yield to conclusive data on residence times and mixing.

Time series increase the lifespan of CFCs for water age estimations.

Based on time series, best-fit procedures can be developed.

POSSIBILITY

Dispersion Model curves with increasing RT (Residence Time) in years for CFC -11
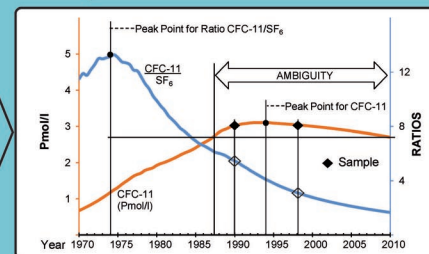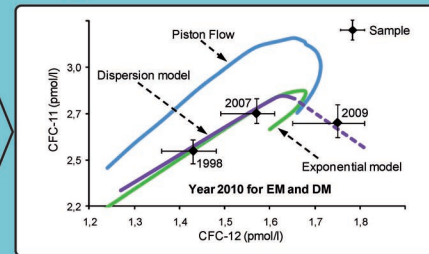

EVALUATION

Transport models need to be used more specifically.

The identification of transport models and transport parameters can help to reduce uncertainty in residence time analysis with CFCs.

Ratios can reduce uncertainty and eliminate ambiguity.
While a sample recharged after 1985 has two possible recharge years, CFC-11/SF_6 ratios differ.

Time series are promising to reduce the uncertainty.

This alone will not eliminate the uncertainty as the Dispersion Parameter is also uncertain, but it will help to identify and differentiate mixing models.